INDUSTRY STUDIES

REPORT

1995

INDUSTRY STUDIES

ACADEMIC YEAR 1994-1995

ADVANCED MANUFACTURING
AGRIBUSINESS
BIOTECHNOLOGY
EDUCATION
ENERGY
FINANCIAL SERVICES
INFORMATION
MUNITIONS
SPACE
ADVANCED MATERIALS
AIRCRAFT
CONSTRUCTION
ELECTRONICS
ENVIRONMENT
HEALTH CARE
LAND COMBAT SYSTEMS
SHIPBUILDING
TRANSPORTATION

The analysis and opinions expressed or implied herein are solely those of the members of the respective Industry Studies Committees based upon their experience and study and do not represent the views of the National Defense University or its constituent colleges, the Department of Defense, or any other U.S. Government agency. This material does not imply Department of Defense endorsement of factual accuracy or opinion.

NATIONAL DEFENSE UNIVERSITY
INDUSTRIAL COLLEGE OF THE ARMED FORCES
WASHINGTON, D.C. 20319-6000

REPLY TO
ATTENTION OF:

INDUSTRY STUDIES PROGRAM

The Industry Studies Program of the Industrial College of the Armed Forces examines the resources component of national security. The students are organized into 18 Industry Study committees which analyze and evaluate defense-essential industrial sectors and assess their ability to satisfy national security requirements in peace and conflict. This effort requires the development of a strategic perspective on the U.S. and global industrial base and its role in supporting the resource requirements of national defense.

Each committee's study is organized around a series of seminars which bring recognized industrial, government and academic authorities to the classroom to focus on critical aspects of the industrial sector. Field study visits to both domestic and foreign industries directly support the research and analysis conducted by each committee. Committees visit prime and subcontractor corporate headquarters, production facilities, government activities, labor organizations, trade associations, logistics and distribution facilities, financial institutions, and research facilities. The international portion adds the dimension of comparative industrial analysis, permitting a realistic assessment of the long-term health of the U.S. industrial sector in the competitive world arena.

At the conclusion of the study, each committee develops an executive summary report; all 18 follow this introduction. The composite report provides a view of the overall status of the industries under study and the relevant policy implications.

Suggestions for other areas of study are earnestly solicited and should be directed to Mr. Gerald Abbott, the Industry Studies Program Director.

John S. Cowings
John S. Cowings
Major General, USA
Commandant

INDUSTRIAL COLLEGE OF THE ARMED FORCES

TABLE OF CONTENTS

INDUSTRY STUDY

#1

ADVANCED MANUFACTURING

Table of Contents

PARTICIPANTS

Students

LTC Jim Allen, USA

Mr. Mike Bates, D/AF

CDR Sarah Brown, USN

Mr. Bob Byers, Dept of Treasury

CAPT John Fink, USN

LTC Mike Gibson, USAF

CDR Rich Jaskot, USN

Mr. Syed Karim, D/AF

LTC Steve Klegka, USA

LTC Dan Lombardi, USAF

CAPT Hugh McWilliams, USN

CDR John Read, USN

CDR Frank Smith, USN

Ms. Carol Wasielewski, D\N

LTC Earl Wyatt, USAF

Faculty

Dr. Linda Brandt

Dr. Clair Blong

COL Joe McCue

PLACES VISITED

Domestic

Raytheon	Boston, MA
Chrysler Technology Center	Detroit, MI
Project Focus Hope	Detroit, MI
Boeing Aircraft Company	Everett, WA
Boeing Computer and Information Systems	Everett, WA
Association for Manufacturing Technology (AMT)	Fairfax, VA
National Institute of Standards and Technology	Gaithersburg, MD
Lawrence Livermore Labs	Livermore, CA
Saturn	Marysville, TN
Silicon Graphics Inc	Mountain View, CA
Lockheed Aerospace Labs	Palo Alto, CA
Museum of American History (Industrial Era)	Washington, DC

International Travel

Cambridge Science Park	Cambridge, UK
British Telecon Lab	Martlesham, UK
Machine Tool Technologies Association	London, UK
British Aerospace	Preston, UK
SNECMA	Paris, FR
SAGEM	Paris, FR
Thompson CSF	Paris, FR

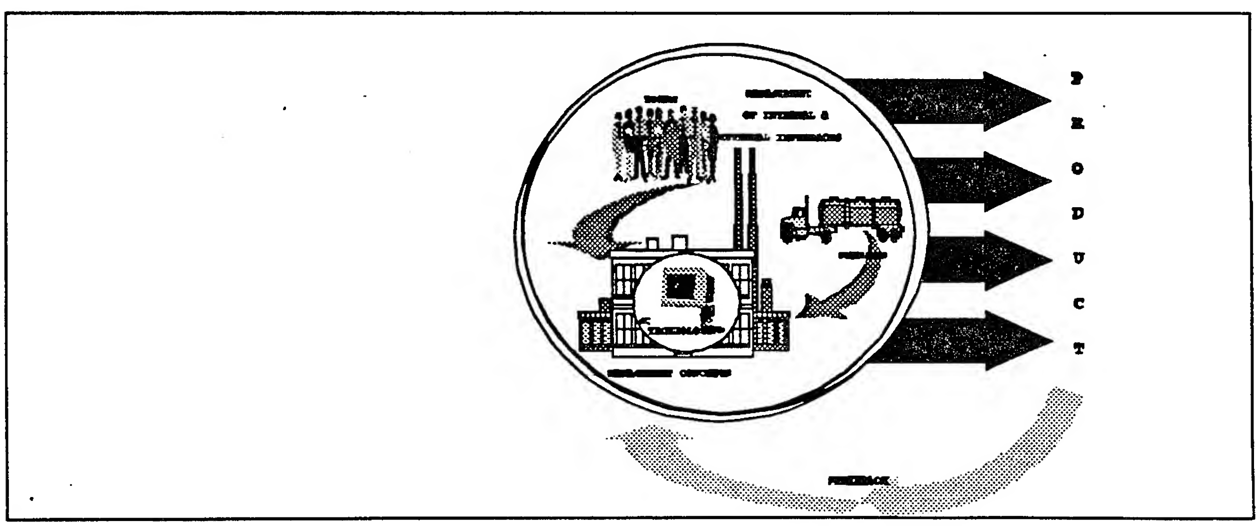
INTRODUCTION

Our industry study group focused on advanced manufacturing capabilities across multiple industries to find common practices and trends. We took on this effort in order to recommend government and industry actions that will ensure a robust United States' manufacturing capability--one which currently makes up roughly 20 percent of the Gross Domestic Product[1] and produces 85 percent of our exports.[2] The results of this exploration are contained in this paper. First, we will address what components make up an advanced manufacturing capability. These components include the management of internal and external interfaces, management concepts, and technology. Second, we will discuss manufacturing industries' trends within these components. Third, given these trends, we will explore the impacts on national security. Fourth, we will pose some questions and challenges facing our Government and manufacturers. Finally, we will recommend government and industry roles and actions in meeting these challenges.

ADVANCED MANUFACTURING

Advanced Manufacturing is not an industry itself, but more properly defined as a "system," which is the total integrated environment needed to successfully compete on the world market in manufacturing.[3] This system has three main components: management of internal and external interfaces; management concepts; and technology. These components work together to produce a product. Customer feedback on product characteristics or quality results in the manufacturer using the various components to redesign the product, create new products, reduce costs, or improve quality. Therefore, these three components are key to a manufacturer's ability to meet customer needs while reducing his own costs in order to make a profit and stay in business.

The management of internal and external interfaces



entails how a company structures the people inside the organization, how it deals with suppliers and other agencies, such as research institutes outside the company, and how it operates in its environment. These interfaces include:

■ *Organizational Structure.* Advanced manufacturing companies are becoming more and more creative in their structures as the demands of competition force business restructuring. Many companies are traditionally structured, like the military, with a hierarchial structure and stovepipe organizations. Others are matrix organized, where people are drawn from multiple organizations to complete a particular project, or lattice

organized with no apparent management structure, just maximum flexibility to allow the natural company leaders to form coalitions within the company to produce new products. There are even virtual companies which are not companies at all, but a conglomeration of different companies, with particular core competencies, who band together for short-term product endeavors. Companies also differ in their approach to using production workers. Some companies maintain the traditional production/assembly line where one worker does one task repetitively, while others establish teams that are given particular tasks and then allowed to organize themselves for task completion.

■ *Employee/Management Relations.* These relations primarily deal with union/management agreements which vary by industry sector and in some instances, by regions of the country. Unions may cooperate with management, especially in broadening the definition of its members' jobs, or hinder management in restructuring manufacturing operations. Company attention to employee training and education are also factors directly tied to its ability to compete in its particular industry. Therefore, there is a strong tie here to external relationships with schools and universities to ensure employee educational needs are addressed.

■ *External Relationships.* Included here are supplier relationships and arrangements with research and trade organizations. Companies must choose whether to employ many suppliers to achieve the lowest cost materials or fewer suppliers to establish long-term quality oriented relationships. They must also decide whether to perform research activities within or outside the company and, where outsourcing is desired, must determine how to work with various universities and Federal Laboratories.

■ *Infrastructure.* Public works infrastructure, as defined by the National Research Council in their 1987 Report on Infrastructure for the 21st Century, includes highways and bridges, railroads, airports, mass transit, water supplies, solid and liquid waste disposal, electric power generation, hazardous materials management, and telecommunications. Advanced manufacturing companies need infrastructure. They assume adequate transportation infrastructure to transfer supplies, raw materials, and finished products between their sources, the manufacturing facilities, and markets is

available. They also assume adequate water, sewerage, electricity, and hazardous waste disposal when planning their manufacturing operations, and depend on effective communications infrastructure to relay information to highly motivated managers.

Management concepts relate to those mechanisms that when combined, effectively produce some product. These mechanisms include:

■ *Material Resource Planning (MRP).* This planning provides manufacturing companies the ability to automatically determine the materials, tasks, and production times to deliver their products. More sophisticated planning systems, such as finite-capacity-scheduling (FCS), can also monitor and adjust the execution of its original plan to deal with deviations. For instance, FCS can look at actual orders and the dynamics of how orders flow through the lines and then identify problem overload spots.[4] Much like the phone company's ability to reroute calls when trouble occurs, these systems can determine and monitor labor requirements, track progress, and identify to the planners adjustments where needed.

■ *Just In Time (JIT) Inventory Practices.* Advanced manufacturers limit inventory stocks and costs via these practices which attempt to deliver needed materials to the right location just as they are needed in the manufacturing cycle. These practices take place not only within the company from machine to machine, but also outside the company with suppliers. This capability is made possible with manufacturing process controls and modern infrastructure and transportation systems.

■ *Flexible Manufacturing.* This is the ability to produce a variety of similar products, in random order, and small batches. Under this practice, it is possible to manufacture the same basic product with a certain degree of customer selectable variation.

■ *Statistical Process Control (SPC).* While MRP and JIT allow control of inventory and resources, SPC allows oversight of product quality though process control. Instead of checking individual parts or products, production workers monitor critical measurements of their process. Then, when those measurements fall outside acceptable levels, the workers take corrective action on the process thus ensuring quality products.

■ *Mass Customization.* "Mass customization is based on the idea of tying computer-based information systems together with new modes of operation such as flexible manufacturing and just-in-time production--and then using those linked systems to make it possible to provide each customer with the attractive, tailor-made benefits of the pre-industrial craft era at low cost of modern mass production."[5] Examples include Motorola's offer of more than 29 million different combinations of pager features per customer demand and Dell Computer Corporation's production of over 14,000 various PC configurations per customer order.

■ *Benchmarking.* This is "the continuous process of measuring products, services, and practices against those of the toughest competitors or companies renowned as leaders. The operational definition of benchmarking is finding and implementing the best business practices to ensure customer satisfaction."[6]

■ *Concurrency.* This practice is commonly defined as teaming, and is closely aligned with matrix organizational structures as defined above. Many manufacturers have abandoned the hierarchial, autocratic management structures in their firms. They have moved to flatter organizations, eliminating the multiple layers between the worker and the decision maker. From a management perspective, they have implemented integrated product teams that combine the functional elements in the firm for the purpose of working a problem or project from conception to delivery in a concurrent fashion. Inherent in this integrated team approach is the ability to respond faster to customer needs because marketing representatives, as well as design, production, support, and finance representatives, are on the team.

Technology relates to the tools of manufacturing, including product and process designs. These tools fall into three prime segments of today's modern manufacturing system: Computer-Aided Design, Engineering, and Manufacturing; Factory Floor Simulation; and Machine Tools. Two of these segments are supported by their own distinct industries, while the third is a subset of the modeling and simulation industry.

■ *Computer-Aided Engineering (CAE), Computer-Aided Design (CAD), and Computer-Aided Manufacturing (CAM).* These techniques provide the hardware and software tools needed to design, engineer, and manufacture products with the aid of computers. They enable complete product design and manufacture in a paperless environment, and, as with the Boeing 777 aircraft, can eliminate the need for prototyping new products. Thus, they virtually eliminate the costly scrap and rework during new product development. These computer support tools are produced by software development houses such as Silicon Graphics and are considered part of a group of computer software products the Department of Commerce refers to as the "package software" industry--a growth industry in terms of people, sales, and suppliers. This industry is decentralized with suppliers in virtually every corner of the country serving markets in communications, health care, information systems, automobile, aerospace, military, transportation, and utility companies.

■ *Factory Floor Simulation.* This second segment of technology recognizes that the manufacturing process includes complex relationships between raw materials, plant layout, inventory,
machines, manpower, and other competition factors. Factory floor simulation techniques strive to model these relationships to support decisions affecting productivity. These computer based simulations, such as SIMFACTORY from CACI Products Co, permit the designers of new plants to set parameters for factory workstations, address material handling equipment, and depict it

all graphically.[7] Another simulation device, referred to as a computer-aided process planner (CAPP), integrates the complex tasks of selecting production methods, tools, fixtures and machinery, sequence of operations, and final assembly.[8] CAPP also enables its owner to efficiently plan and schedule manufacturing operations. Design of these simulations is carried out by the same "package software" industry that produces CAE/CAD/CAM tools, and is finding a niche within those companies specializing in virtual reality simulations.

■ *Machine Tools.* This technology segment supplies the power driven machines used to cut, form, or shape metal and other materials such as composites, graphite, plastics, and ceramics.[9] These machine tools form the core of advanced manufacturing and are termed "mother machines" because virtually all manufactured products are made by them or by machines that are made by them.[10] The machine tool industry exists to design, develop, produce, and deliver these machines. As such, "the machine tool industry is the belt that holds up the pants of industrial America"[11] because it supplies these "mother machines" to all manufacturing industries be they automotive, aerospace, or electronics. Therefore, this is a strategic United States industry with unique structure, conduct, and performance features.

Structure. Small family owned firms dominate the machine tool industry. For instance, "85 percent of these firms have less than 100 employees and only 4 have more than 1,000 employees."[12] There are some 475 companies operating 550 machine tool plants. To give a feel for the size of the industry, "If the total 1988 shipment of the entire industry ($2.4 billion) were attributed to a single company, it would rank only 267th in the fortune magazine list of the 500 largest companies--about the size of Revlon."[13] The industry stays small due to entry barriers associated with the expense of research and development and the integration of expensive CAE/CAD/CAM systems with its tools. The industry itself is highly concentrated, with 12 firms producing 57 percent of sales[14] and tends to follow the aerospace and automotive industries, preferring locations around the Great Lakes region. Due to this following, machine tool demand and sales are dependent on these other industries capital equipment investments.

Conduct and Performance. The industry's tendency to follow the aerospace and automotive industries creates elastic production demand and resulted in a downturn in sales in the 1980s. This downturn, coupled with the industry's focus on high priced, high technology machinery allowed the Japanese to take a large US market share in low priced, relatively simple equipment. US sales of machine tools dropped from a high of $5.6 billion in 1979 to only $1.4 billion in the early 1980s.[15] As a result, first President Reagan, and subsequently President Bush, enacted Voluntary Export Restraints[16] to allow US machine tool makers time to regroup and regain sales--and it did. While still working to improve products

and regain further sales on low price products, the industry continues to pursue high priced, high technology equipment. As such, the US is dominating the global market in the design and manufacture of highly sophisticated and specialized machines, as well as Computer Numerically Controlled (CNC) software.

TRENDS

We noted many trends in the various components of the advanced manufacturing system. Overall, these trends point to extremely information-intensive, flexibly organized manufacturers operating in a highly competitive world, not just a national environment.

Management of Internal and External Interfaces

■ *Manufacturers Going Global.* American manufacturers are increasingly becoming global manufacturers, relying on overseas sales to stay in business. However, selling overseas forces new rules on American companies. In many instances they are forced to enter partnerships with companies in the countries they want to sell to in order to enter that market. Also, because international trade agreements are not uniform across the globe, our companies face a disadvantage in sales where US trade doors are open and other countries' doors are only ajar. Finally, with internationalization comes concerns over proprietary rights, as highlighted by product pirating in China.

■ *Virtual Companies.* Manufacturers are beginning to identify their core competencies (what they are really good at) and form short-term relationships with other companies (who contribute their core competencies) to produce a particular product. This is made possible with information technology and powerful communications links which permit people and resources to be added or removed readily from a venture.[17] At the heart of the virtual company is the idea of concurrence in design and manufacturing, aided by standardized data transfer and telecommunications. Virtual companies promise to be the ticket to future competitiveness in manufacturing which will allow America's industrial base to flourish.

■ *Employment Down, Productivity Up.* US manufacturing companies are reorganizing and downsizing. In 1950, over 34 percent of the American labor force was employed in the manufacturing sector whereas only about 17 percent is employed today;[18] however, manufacturing industries have still maintained their 20-percent contribution to our Gross Domestic Product. This downsizing is primarily accomplished through employee lay-offs and the selling of unprofitable businesses. Companies are making up for the reduction in employees with improvements in processes. We heard from one automotive company that they intend to produce a new 1996 model at the same rate as their 1995 model, with 1000 fewer employees--a feat accomplished via

process improvements. However, coupled with these process improvements is the need for companies to change their organizational cultures. These changes, which call for flatter, more flexible organizations, are difficult given existing worker/union/management laws and relations. Additionally, these flatter, leaner organizations, with reduced layers of management, multiple-skill positions, and increasing application of technology, require more adaptive and highly skilled workers.[19]

■ *Workforce Unprepared for Advanced Manufacturing.* American public education is not preparing its students with the skills required to keep US industries advancing in the competitive global markets. While only 21 percent of the positions in the 1992 job market required advanced mathematics, language, and reasoning skills, the estimates for those same requirements in 1999 will be 41 percent[20]. Our high school graduates are increasingly ill-prepared for a workplace where technology is steadily raising the basic skill levels required for entry-level positions. At the same time, skills of experienced workers are becoming obsolete. Industry representatives outlined deficiencies in a number of areas, especially mathematics, communications, and teamwork skills. This is consistent with Scholastic Aptitude Test (SAT) average scores for high school seniors which have inched up over the past three years but still remain lower than 20 years ago.[21]

■ *Manufacturing Unhindered by Infrastructure.* Accompanying a decline in infrastructure spending during the 19'70s and 1980s was a noticeable decline in national productivity growth; however, the manufacturing sector experienced little change in growth. For instance, during the 1950s and 1960s, US manufacturing labor productivity growth matched the national rate of about 2.8 percent. Both of these rates slowed during the 1970s along with those of every other industrial nation, but during the 1980s manufacturing productivity growth surged to the point where the average was above 2.8 percent.[22] Therefore, other industries such as services, construction, and mining are holding down productivity--not manufacturing. Further, infrastructure spending can not be singled out as the cause of reduced productivity growth. There is, however, universal agreement that the move toward a US infrastructure multimodal system, where there is commonality and smooth transfers between land, sea, and air transportation, provides an enabling environment for continued economic growth and quality of life.

■ *DOD Moving to Commercial Practices.* The decline in defense research and development and procurement spending (down almost 65 percent from the 1980s[23]) has caused the DOD to reform its acquisition practices and embrace commercial products and practices as a way of reducing costs. This trend, while welcomed by the manufacturing sector, presents some problems as commercial companies have not welcomed the oversight accompanying these new relationships. For example, one major commercial electronics manufacturer refused to deal with DOD on the sale of its radios during Desert Storm/Shield because of the associated government paperwork.

This resulted in Japan buying these radios and giving them to US soldiers.

■ *Defense Industry Conversion.* Accompanying DOD's move toward more commercial products are the US Government's initiatives to help defense manufacturers transition to commercially-oriented products and services. Some of these initiatives are:

The Technology Reinvestment Project (TRP), led by the Advanced Research Projects Agency (ARPA), is aimed at stimulating the transition to a growing, integrated, national industrial capability. TRP projects are cooperative projects between federal government bodies and industry which are intended to take advantage of cost-sharing arrangements to create new technologies, disseminate that technology, and provide manufacturing education and training.

The Manufacturing Technology Program, another defense effort led by ARPA, is an effort to provide dual-use (applicable to defense or commercial industries) manufacturing technologies. Its major areas are electronics manufacturing, materials, processes and structures technologies, and information and agile manufacturing technology.

The Manufacturing Science and Technology (MS&T) Program, sponsored by DDR&E, strives to "make affordable mission capability a practical reality by expanding DOD access to a capable, responsive, multi-use industrial base with efficiencies comparable to world-class commercial firms."[24] It is designed to work in areas that are driven by defense essential needs, such as large caliber weapons technology, but are beyond the normal risk or interest of industry. MS&T technical efforts fall in three broad areas: manufacturing engineering systems, manufacturing processing and fabrication, and advanced industrial practices.

Advanced Technology Demonstrations are government funded efforts to demonstrate new capabilities in areas such as advanced computer-aided engineering systems, flexible manufacturing systems, advanced manufacturing simulations, and information integration among networks of computers.[25] Although conducted on products of military interest, such as sensors and guidance systems, these demonstrations are applicable to both commercial and defense industries.

■ *Increasing Foreign Investment.* Foreign direct investment (FDI) has significantly increased in the US. The data indicates that while foreign-owned establishments account for only 4 percent of US business employment, it accounts for 7 percent of

US manufacturing employment. In a very small number of industries such as hydraulic cement and noncellulosic organic fibers (which consists mainly of polyester and nylon manufacturing) FDI accounts for over 50 percent of the employment.[26] The increase in FDI has caused growing congressional fear that foreign acquisitions are sometimes motivated by a desire to obtain technology. Unregulated FDI may result in the takeover of technologies considered critical to national security.[27]

Management Concepts

■ *Little Long-Term Planning.* Long-range strategic planning is not done well in the US despite the fact that such planning is a fundamental element required for the long term success of any enterprise. Based on our visits to commercial firms, we observed few organizations doing what we consider strategic planning--the process of deciding what an organization should be doing in order to achieve its purpose. When asked to describe their planning process, most of these firms responded with their recurring business planning process, with no one really looking beyond the next five years. The result is a focus on quarterly earnings and profit reporting to their stockholders.

■ *Flexible, Information-Intensive Manufacturing.* "With speed and flexibility that leave the Japanese agog, US manufacturers have come roaring back after years in eclipse. The secret? It's the software, stupid."[28] US manufacturers have begun outdistancing foreign competitors in critical measures such as time to market and manufacturing flexibility. They are seizing back the global lead as software rather than hardware begins to dominate manufacturing and allows them to use and capitalize on those management practices described above. In particular, many companies are supercharging their material resource planning (MRP) systems with finite-capacity-scheduling (FCS) as the performance wave of the future. Information technology has stormed the American factory and created a new, efficient, flexible manufacturing paradigm. The new paradigm is a balance in which software and computer networks have emerged as more important than production machines, in which robots play a supporting role and in which human workers are back in force.

Technology

■ *Paperless Manufacturing.* Information technology coupled with advances in CAE/CAD/CAM have made the modern factory essentially a paperless environment. Advanced manufacturers are designing, prototyping, and even testing new products via computer, then transferring the manufacturing data directly to the factory floor. In fact, American companies dominate the new market for rapid-prototyping machines which are computer driven units that fabricate parts directly from design data. With the

proliferation of such systems in the manufacturing sector has come increasing pressure for an overall "industry standard" architecture for computing systems. Such standards provide for the uniformity of component parts that enabled the US to propel

itself through the industrial revolution. The need for commonality of languages, compatibility of databases, and accessibility of information from "outside" databases is an imperative for further productivity gains. In short, the trend is toward integration and standardization of all automation activities used in manufacturing.

■ *More Simulation.* In the future, simulations are going to have a much larger visibility in the organization as the power of the model grows and comes to be used by more people. Tomorrow's industrial engineer will be responsible for linking simulation to all other manufacturing tools and everyone's decisions on scheduling, layout, operations, etc., will be based on the results of the model. Therefore, the industrial engineers' role will evolve to one of coach versus technocrat.[29] The use of simulations is also consistent with the trend toward leaner, flatter organizations relying on teamwork to produce products. Simulators will provide the factory workers the tool that allows them to participate in the decision making process and make more productive contributions to the organization.[30]

■ *Information-Intensive Flexible Machine Tools.* "The primary focus in the machine tool industry is on computer controls and reducing the number of times a work piece must be repositioned during the production process."[31] This focus compliments the trend in manufacturing industries to shorten product design and development cycles, and provide more variety of products in smaller production runs (mass production in lots of one seems to be the aim).[32] Therefore, the machine tool industry focuses on machines that are flexible, can be integrated with various information sources, and minimize set up time. As such, the physical age of machine tools is no longer the driving force of obsolescence as improvements in material technology mean that machines simply do not wear out as quickly. But, obsolescence is measured by the capability of the machines' controller and its ability to communicate in a paperless factory environment. The result of these last two points, coupled with the elimination of investment tax credits and alterations in depreciation allowances, is industries have no incentive for major machinery upgrades. Consequently, the average age of US metalworking machinery has reached a 20 year high. However, they have constantly improved machine controller software (often without any standardization in programming between machines, factories, or suppliers).

■ *Humans, not Robots.* IBM executive L. Ray Mays says it best, "We're not as enamored with automation as we were in the early 1980s. We did a lot of research about what's reasonable to automate and what isn't. We found that it's much more cost efficient to use hand labor with software networks than to use robots, for example. We've learned that in dealing with odd size components and tight tolerances, humans are more efficient than robots."[33] The result, US manufacturers now use three times as much software as the Japanese and use robots for simple jobs at which they excel (which are often hazardous to humans) such as spot welding and painting.

IMPACT ON NATIONAL SECURITY

Given the trends described above, what are the impacts on our national security? First, trends in ***Management of Internal and External Interfaces*** poses both positive and negative impacts. The positive impacts of globalization offers the opportunities to:

*Cost share through shared R&D, thereby leveraging the industrial base of our allies.

*Integrate allied operations through weapon system cooperative agreements

*Enhance the defense conversion environment through the creation of new foreign markets for defense manufacturers.

Additionally, the infusion of productivity enhancements already achieved in the commercial sector, into the defense industry will result in lower cost efforts for the Government. Most importantly, however, is that with the Defense Department's move toward commercial products and as the defense industry moves toward dual use technology and commercial practices, comes the opportunity to significantly decrease government costs of weapon system procurement. With these reduced costs also comes a greater availability of products from multiple manufacturers--a significant benefit should we need to mobilize industries during a crisis.

However, there are downsides to these trends. With the move toward commercial products comes the question of whether commercial companies will even deal with the government given its penchant for oversight and regulation, as well as the question about its ability to mobilize national resources without special congressional action. Not only do we have to worry about mobilizing global companies, but we may not even be able to identify the components of virtual companies that exist for only a short time. Finally, with globalization and foreign ownership of US companies comes concern over the loss of critical technologies and the fear that we may not be able to mobilize resources which are located overseas, but which may be critical to national defense. Compounding the loss of critical technologies are future management concepts that rely on the abundance of information which will be accessible worldwide.

The ***Management Concept*** trends toward short-term planning and flexible, information-intensive manufacturing also pose positive and negative impacts on national security. Particularly positive will be government's ability to obtain small lot size, customized products off of commercial lines at market prices using information which is transferrable between manufacturers; therefore, allowing us to reverse the 6- to 7-percent growth in production costs since World War II. This is a significant capability given the defense share of US manufacturing is roughly 2.1 percent (down from 10 percent) and no longer commands even a reasonable price.

Negatively impacting national security is the lack of any industry long-term planning. This lack of planning is compounded by the US Government's ten-year budgeting horizon which focuses primarily on the next two years. Both of these facts prevent planning and predictability regarding defense needs and could result in our inability to adequately meet future threats with technologically superior off-the-shelf products.

The ***Technology*** impact on national security is purely positive. Computer aided design and manufacturing, greater reliance on simulation, and the electronic flow of information have the potential for greatly shortening weapon system design and production times, thus allowing us the ability to upgrade or renew equipment more often. Current acquisition cycle times of 16 years should be a thing of the past.

ADVANCED MANUFACTURING QUESTIONS/CHALLENGES

The trends toward global, information-intensive, flexible manufacturing described above pose many questions/challenges that US manufacturers and government should be considering. Although they are probably apparent, we will enumerate them here before presenting possible industry and government responses.

Management of Internal and External Interfaces

■ *Global Trade.* How do American manufacturers level the world playing field, overcome barriers to globalization, and protect the integrity of our products? The uneven playing field comes from various countries' trade practices that hinder the entrance of US products; however, this is not the only barrier to our manufactures. Many barriers come from within the US and consist of:

*Nationalistic practices, such as the "Buy American Act." which inherently restrain foreign trade. Enforcement of this act has caused our trading partners to conclude that the US talks a good game when encouraging free trade, but in fact remains a closed shop.

*Export controls which hinder the growth of American companies by restricting their ability to sell products abroad. Such controls are maintained to prevent the outflow of critical technologies and products like nuclear weapons and fighter aircraft. These controls are often placed on technology and products readily available elsewhere on the world market, thus putting our manufacturers at a competitive disadvantage.

*Excessive regulation, particularly environmental controls, which impede economic growth in the global market. While an appropriate level of government regulation is desired to force innovation and competitiveness

in our factories, too much puts nonrecoverable costs on our manufacturers, and places them at a disadvantage in comparison with other countries who are less stringent.

■ *Global/Virtual Companies.* What does the Government owe US-based global companies, especially those which are foreign owned, or the virtual company which has no long term standing? If it still takes government-to-government negotiations to manage trade agreements between countries, how does the US Government negotiate with a global or virtual company?

■ *Employment.* How can high-paying manufacturing jobs be created or maintained given leaps in process improvement? Can workers be reduced so far as to impact consumption of manufactured products (e.g., if no one works, who buys the products)?

■ *Education and Training.* Where are future advanced manufacturing workers going to come from? There is a remarkable consistency in the competencies manufactures list as most essential to raising productivity.[34] At the top of everyone's list: fundamental mathematics, reading, and communication skills which are deemed absolutely essential to further technical learning. Also high on the list: basic computer skills, teamwork (or "collaborative") skills, inter-personal skills, and a knowledge of the basic employee responsibilities. As we are already shown, American high schools are not producing this type of employee and some companies are already turning to students with college Associate Degrees as production workers.

■ *Infrastructure.* How can public infrastructure keep pace with manufacturing demands/growth?

■ *Manufacturing Initiatives.* What is government's role in advancing manufacturing tools and techniques? Should it engage in the "free market?"

■ *Defense Conversion.* How do we complete defense conversion and ensure a robust defense industrial capability that supports our national security strategy?

■ *Technology Transfer.* How does the US protect critical technology transfer, hence national security, given increased foreign direct investment in US companies?

Management Concepts

■ *Strategic Planning.* Do manufacturers need to take a longer-term focus on their business and capital investments to insure growth and market share? Unless they are able to look to the future and decide what they want to achieve, they will be stuck with someone else's future.

■ *Manufacturing Practices.* What is the best method of integrating all

manufacturing practices to gain the greatest synergy between them for increased productivity? These practices, and the information technology responsible for them, place US manufacturers 5-10 years ahead of foreign manufacturers, but they can ill afford to be complacent with the current state of their processes.

Technology

■ *Information Intensity.* How can US industry insure communication between "islands" of information to reap the benefits of investments in information technology, factory automation, and management practices such as Just-In-Time? These "islands" include CAE/CAD/CAM, factory floor simulation, and machine tool software programs. The ability of these programs to talk to each other will be a must in the paperless factory.

■ *Capital Investment.* Can manufacturers be encouraged to invest in new capital equipment to keep ahead of world competitors and support the US strategic machine tool industry?

MEETING THE CHALLENGES

Now let us consider industry and government roles, actions, and policies in addressing the questions/challenges raised above.

Management of Internal and External Interfaces

■ *Global Trade.* The benefits of globalization outweigh the risks of economic interdependence in the post-Cold War era. Industries role is to actively seek partnerships and use the talents and innovation gained through international cooperation to maintain their competitive edge. The Government must also act responsibly in maintaining a balanced approach between national security interests and the need to gain a competitive advantage in world markets. The US can reduce its strategic vulnerability created by interdependence in the global market by developing alternative resources, stockpiling strategic items, and diversifying our supply sources. Specific Government actions include:

■ *Assist American industry internationally.* This recommendation has two prongs. First, we must help industry assess international competition. We agree with Laura Tyson's premise that the US needs to develop an institutional mechanism for assessing competitive and technological trends in global high technology industries on an ongoing and timely basis, and not rely on American industry groups (who are biased to their industry) to provide that information. A restructuring of the Department of Commerce would achieve this end. Second, the Government needs to continue efforts to "level the playing field" globally for US companies. The North American Free Trade Agreement (NAFTA), the General Agreement on Tariffs and Trade (GATT), the

Asia Pacific Economic Cooperation (APEC), and the US-Japan Framework Agreement are great starts to achieve this result, but the US should institute the same tit-for-tat constraints on foreign investors in the US as on US companies abroad. The Government also needs to strengthen international laws on proprietary rights to protect American investments.

■ *Repeal the "Buy American Act".* This 1933 act, fostered during the Great Depression, is a relic of American sentiment and a restraint to foreign trade. This act goes in the category of tit-for-tat in that if America wants free trade abroad, it must open up free trade in the US and allow direct foreign sales to the government. The result should also be lower cost, allied-compatible weapon systems.

■ *Reevaluate strategic technologies and ease export controls.* In today's world, commercial technology is beginning to exceed technology in the military sector and with globalization, everyone including our adversaries, has access to the same commercial technology base. As dual-use (commercial/military) strategies become more prevalent, the ability to apply commercial technology to defense projects will be within reach of most industrialized nations. Thus, export controls in some manufacturing areas hinder growth of US companies, and provide no real strategic advantage.

■ *Issue a Presidential Review Directive of all Federal Regulations impacting manufacturers and eliminate those that restrict, rather than challenge innovation.* We particularly need to target those Federal Acquisition Regulations that are outside of normal business practices, and burden a contractor with excessive oversight. If we are to accept best commercial practices in design and manufacturing, we should accept best commercial practices in contracting.

■ *Employment.* Closely aligned with globalization is the creation of new jobs. Business, not government creates jobs. Government only creates the business environment. Therefore, government's role, as described above, is to create the environment for businesses to compete and sell globally. The result, according to the US Department of Commerce, is that 20,000 new domestic jobs are created for every $1 billion worth of exports. These new jobs in export industries pay wages that are 22 percent above the economy-wide average.[35]

■ *Education and Training.* Short-term government assistance to retrain our workforce combined with long-term government and industry funded education is the only way to retool the human resources for the future. From a government perspective, the Department of Education should collect industries' requirements on worker skills and relay that information to educational systems across the country. We also need to pursue and fund modern vocational education to train technicians who choose not to obtain a college degree. Father Cunningham's Focus Hope in Detroit, MI might be a model for such endeavors, particularly in the short run where he has

instituted a FAST TRACK program to bring entrants up to a 10th grade math and reading level, and then offers machinist training and longer-term engineering training to students with the aptitude and ambition for it. This education and training is virtually cost free to the student. The focus of such education is "getting kids into the workplace to learn by experience, and giving vocational students academic basics of the same caliber that college-prep students have."[36] Additionally, although unpopular, the US Government needs to consider tying educational funds sent to states to US-wide educational standards that ensure high schools graduate high school capable students. Business, on the other hand, must continue to pursue educational partnerships as an attempt to influence curriculums. These partnerships should include: *Helping Hand Relationships,* in which business provides money, equipment, speakers, tutors, and other goods and services to local schools; *Programmatic Initiatives*, where business attempts to change and improve one school or program; *Compacts and Collaborative Efforts,* which are usually joint efforts of a number of businesses with a school or school district; *and Attempts to Alter Government Policy,* which normally has business leaders organizing or participating in commissions and task forces to set or change educational agendas. Both business and government must also recognize that the "people at work today comprise the majority of the workforce for most of the next two decades. Therefore, their training will have the greatest effect on current national competitiveness."[37] As a result, business and government (particularly in retraining defense and defense industry workers) must devote sufficient resources to retraining, for technology innovation creates new jobs as it destroys old ones and those countries which do not possess a national system for training and retraining will probably find themselves more disadvantaged than they are now.[38]

■ *Infrastructure.* Given manufacturing's past growth, in spite of a reduction in infrastructure spending in the 1970s and 1980s, there is no reason to assume that more investment in traditional infrastructure, such as a second interstate highway system, will yield the same benefit as the initial investment. Recent searches for infrastructure investments which have the greatest potential return have locked onto systematic improvements of existing structures, not the creation of massive new infrastructure. Therefore, we advocate the Department of Transportation author a strong federal policy directing state and local governments to concentrate infrastructure investments on rehabilitation of existing routes for commerce, and to alleviate urban congestion through vehicle occupancy restrictions, user tax collection technology, or mass transit alternatives. Further, we support the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) which directs the investment of $155 billion over six years to improve the interfaces between sea, rail, and highway transportation of cargo, without building a single new seaport, railroad, or highway. The efficiency improvements targeted by ISTEA are exactly the type of infrastructure investments which will benefit a manufacturing sector seeking to improve productivity by improving process. Another such effort which we support is the proposed "Information Superhighway" and the government's approach to funding primarily with

private financing. This initiative will also improve public infrastructure to the benefit of manufacturing through the standardization of telecommunications interconnections and access.

■ *Manufacturing Initiatives.* Whether it is by process or machinery, "stimulating improvements in science and technology is a widely acknowledged role of government. Research and development cannot be left solely to firms because the benefits to the national economy exceed those to individual firms due to spillovers."[39] We support those government initiatives, such as the Technology Reinvestment Program, geared toward defense conversion, and advocate continuance of those efforts that directly contribute to manufacturing process improvement.

Government efforts also include direct funding, grants and help for manufacturing applications and liaison, coordination, and information dissemination via:

*The Defense Manufacturing Council whose objectives are to accelerate implementation of acquisition reform, industrial base, and S&T initiatives in weapon system programs

*The National Science and Technology Council which develops an integrated defense manufacturing strategy and identifies resources to execute it.

These two councils are DOD's direct links to the manufacturing sector, and bridge the government/commercial gap for national security and mobilization purposes. Further, DOD "has a major role in funding the development and application of advanced manufacturing technology predicated on its need for high quality goods produced expeditiously and efficiently."[40] Also, because it is ultimately in DOD's best interest to do so, we recommend continued shifting of R&D dollars from defense to private industry, and expanding Cooperative Research and Development Agreement (CRADA-joint government and industry research projects) opportunities to make federal laboratory capabilities available as sources of competitive information and help.

■ *Defense Conversion.* In parallel with efforts to covert defense industries to commercial practices and products are the industries' struggle to rightsize as government R&D and procurement are reduced. While specific defense industries have to determine their own core competencies, profitable business units, and best organizational and manufacturing practices, our government must ensure that the rightsized industry meets national security needs and must also foster an accepted business environment. Although we recently heard a very senior DOD official remark that the defense industry was rightsizing nicely without government intervention, we question whether the DOD can rely on rightsizing to occur naturally given the need to retain some unique design capabilities, particularly for fighter aircraft and submarines. Therefore, we recommend DOD determine what critical technologies they need to preserve in the defense industry and then prepare a strategy on how to keep these

technologies alive in a rightsizing environment. We are particularly concerned with retaining design capabilities vice manufacturing, which calls for rethinking how they spend R&D vice production dollars. We also call for a reevaluation of the DOD's in-house R&D capability versus what industry could provide, and needs to provide to remain in business. Second, as far as fostering a new business environment, we embrace current acquisition reform initiatives. This was a common call from every contractor we spoke to. These reforms reduce their costs, hence the Government. In particular, the DOD needs to continue policies that reduce contractor oversight and implement accounting systems that are more closely aligned with industry. They need to pursue those systems which provide simple, accurate information to managers to make knowledgeable program decisions. Additionally, they must step up efforts to use performance specifications instead of MIL-SPECS and integrate more commercial off-the-shelf items into US weapon systems.

■ *Technology Transfer.* Without a doubt, foreign ownership of US companies results in the technology loss abroad; however, the advent of the "third wave," information, makes this loss inevitable even without foreign investments. Where it is in our best interest to do so, we have the ability under the Exon-Florio Amendment (which authorizes the President, under certain circumstances, to take action to prevent ownership from impairing the national security interest of the US) to prevent the sale of a US company to foreigners. We nonetheless advocate restraint of this amendment's use. We recommend that the financial health of a US company be carefully considered before restricting foreign investment in it, because if the company is forced out of business because it cannot attract outside investment, the loss to the US industrial base may be a greater harm to national security than surrendering some control of the company to foreign investors to keep it viable. We propose other solutions to protect high technology aspects of the US company. These solutions range from selling the high technology part of the company to another US concern, to classifying specific technologies, because many times the high technology piece of the company is just a small fraction of its gross business. In any case, we recommend DOD and the Dept of Commerce jointly identify critical technologies and tighten up the process to evaluate US company sales to foreigners.

Management Concepts

■ *Strategic Planning.* We advocate business and government alike engage in strategic planning. Individual manufacturers must decide on what their core competencies are, where they want to be in 5-10 years, then chart a course. The government could encourage companies to take a long-term focus by eliminating quarterly earning reports and moving to an annual report. Companies would then be somewhat relieved of short-term profit pressures, and be more willing to invest long term and make plans to do so. The government also must engage in a longer than two year budgeting horizons in order to lend some predictability in its actions, particularly for defense needs. We must therefore commit to a National Defense

Strategy. In the absence of such strategy and lacking a vision for future force structure, industry will decide what we need. We must flow our defense needs from the top down--government to industry. Once our strategy is set, defense planning guidance should reflect needed force structure that can then be relayed to industry in a coherent manner. Mr. Norman R. Augustine, CEO of Martin-Marietta, in testimony before the House National Security Committee on the National Security Revitalization Act on January 19, 1995, said it best when he remarked that we should make it very difficult to start new programs, but once started, we must commit the resources to provide program stability, thus predictability in our actions. To accomplish this predictability, we'll need to strengthen the DOD Joint Requirements Oversight Council to ensure only the most effective weapon systems or modifications are pursued and avoid duplication of service capabilities. Also, and most importantly, we must push Congress for multi-year budget lines for specific programs. This last initiative will aid defense industries and commercial industries who support defense to plan better for their future.

Technology

■ *Manufacturing Practices/Information Intensity.* We have combined this management concept and technology component because the key to both is their ability to communicate in the information age. This key takes the form of information standards that provide the same uniformity between software operating systems as component part standardization did to enable the US to propel itself through the industrial revolution. As with component parts, information standards are usually publicly recognized and generally accepted guidelines and specifications that govern the design and manufacture of products. Their use ensures a degree of compatibility, performance, quality, and safety of the product, thus the ability to link customers, manufacturers, and suppliers globally into a seamless web. Because the government is no longer the leading purchaser of electronics, we do not feel that its National Institute of Standards and Technology is in a position to write such standards. Therefore, we advocate that industry associations take on the task, and move toward adoption of "open architecture" standards vice those that proliferate proprietary links. Such standards will give manufacturers the ability to mix and match software systems according to their own requirements. Government can help to some degree and has done so through initiatives such as DOD's Computer-aided Acquisition and Logistics Support (CALS) program which has already created an Electronic Data Interchange standard. Once again, such initiatives fall under those previously discussed as part of Defense Conversion. Our government must also be involved in the process by negotiating trade agreements based on common information standards.

■ *Capital Investment.* We have already eluded to solutions in this area, but will reiterate them again. First, manufacturers must plan their future and determine capital investment strategies. Equally important, they must strive for standardization of software to reap the full benefits of computer-assisted design and flexible

manufacturing. Government can encourage capital purchases by decreasing the focus on short-term profits by moving to an annual company report (to accompany their tax information). Additionally, government can encourage capital expenditures by reducing capital gains taxes on equipment and modifying depreciation deductions so companies can recoup investment costs sooner. All these steps have the affect of renewing American factories and preparing them for global competition.

CONCLUSION

America's advanced manufacturing system is healthy and its outlook is bright. Our world lead in information technology is allowing us to link the internal and external interfaces, management concepts and technology components of the system to form a highly flexible manufacturing capability. This flexible capability allows rapid response to global market conditions, permits mass customization, and makes economical production lots of one a reality. But there is still much to be done to ensure a robust US manufacturing capability. Our workforce must be prepared to meet the information and organizational challenges of tomorrow, our infrastructure must be upgraded, and manufacturers must renew aging equipments. Most importantly, however, is the need to standardize information systems so they can best support each other, and create an environment in which buyers, manufacturers, and suppliers can efficiently and rapidly communicate with each other.

ENDNOTES

1. Economic Report of the President, United States Government Printing Office, Washington, DC, 1994, p. 28.

2. Father Cunningham at Focus Hope, Detroit, MI, 17 Mar 95.

3. "Industry Study Report, Advanced Manufacturing," Industry Study Group 9, 27 May 94, p. 9-5.

4. Stevens, Tim, "Success Runs on Schedule," Industry Week, Aug 15, 1994, p. 83-88.

5. Yovovich, B.G., "Mass Customization Sparks Sea Change," Business Marketing, Nov 1993, p. 43.

6. Camp, Robert C., "A Bible for Benchmarking by Xerox," Financial Executive, Jul/Aug 1993, pp. 24-27.

7. Nwoke, Ben U., and Del R. Nelson, "An Overview of Computer Simulation in Manufacturing," Industrial Engineering, Jul 1993, pp. 43-45.

8. Kalpakjian, Serope, Manufacturing Engineering and Technology, 1992, Addison-Wesley Publishing Company, pp. 1-2.

9. "Industry Study Report, Advanced Manufacturing," Industry Study Group 9, 27 May 94, p. 9-5.

10. "Advanced Manufacturing Systems," Briefing to ICAF, 26 May 94, Slide 13.

11. The Association for Manufacturing Technology, Vision 2000: A Winning Strategy for America's Manufacturing Machine Industry, undated.

12. "Advanced Manufacturing Systems," Briefing to ICAF, 26 May 94, Slide 14.

13. Executive Research Project F15, The US Machine Tool Industry, Doumit, Lt Col Patrick F. , USAF, 1993, p. 11.

14. "Advanced Manufacturing Systems," Briefing to ICAF, 26 May 94, Slide 13.

15. "Advanced Manufacturing Systems," Briefing to ICAF, 26 May 94, Slide 14.

16. "Beating Back Predatory Trade," Alan Tonelson, Foreign Affairs, July/August 1994, p. 129.

17. Earls, Alan R., "Agile Manufacturing Finds Firmer Ground," Computer World, Feb 28, 1994, p. 93.

18. US Department of Labor,Bureau of Labor Statistics, The American Workforce: 1992-2005, Apr 1994,p.72.

19. Boyett, J. H. and H. P. Conn, Workplace 2000: The Revolution Reshaping American Business, 1991, Plume, New York , NY.

20. Segal & Troy, "Look Who's Ahead of the Learning Curve," Business Week, 1992, pp. 92-98.

21. "Transition From School to Work: Linking Education and Worksite Training," Executive Summary of GAO Report, #GAO/HRD-91-105.

22. Sanders, Heywood T., "What Infrastructure Crisis?," The Public Interest, 1994.

23. Brandt, Linda S., Ph.D, "Defense Conversion and Dual-Use Technology: The Push Toward Civil-Military Integration," Industrial College of the Armed Forces, Oct 30, 1993.

24. Cundiff, Dan, "Manufacturing Science and Technology (MS&T)" brief to Captain Hugh McWilliams, USN, Mar 22, 1995.

25. Committee on Industry and Technology of the Federal Coordinating Council for Science, Engineering and Technology. Advanced Manufacturing Technology: The Fiscal Year 1994 Federal Program in Manufacturing Science, Engineering, and Technology, Aug 1993, pp. 30-39.

26. Bureau of Economic Analysis and Bureau of the Census, Foreign Direct Investment in the United States, Washington DC, US Government Prining Office, June 1992.

27. Floor Statement of James J. Florio on Trade Bill of 1988, Apr 21, 1988; Also Statement of J. James Exon, Congressional Record, Apr 27, 1988.

28. Burger, Hartmut W., "Information Technology and Manufacturing: Toward New Ways of Working in the Era of Consumer Sovereignty and Globalization," Cost Engineering, Vol 35/No. Nov 11, 1993.

29. Norman, Van B., "Future Directions in Manufacturing Simulation," Industrial Engineering, Jul 1992, pp. 36-37.

30. Ibid, pp. 36-37.

31. Panel on the Government Role in Civilian Technology, Committee on Science, Engineering, and Public Policy, The Government Role in Civilian Technology: Building a New Alliance, National Academy Press, Washington, 1992, p. vii.

32. "Manufacturing Technology: On the Cutting Edge," The Economist, Mar 5, 1994, p. 4.

33. Teresco, John, "Robot, Poised for New Work," Industry Week, Dec 7, 1992.

34. Day, C. R., Jr., "Maybe health care isn't the 'crisis'", Industry Week, May 16, 1994, pp. 53-59.

35. "International Trade and Foreign Investments," International Business, Vol 6, Issue 11, Nov 1993, pp. 86-88.

36. Manserus, L., "New pressures on vocational education," The New York Times, Aug 7, 1994, Sec 4A, pp. 14-16.

37. Jasinowski, J., Workforce Readiness, How to Meet Our Greatest Competitive Challenges, Dept of Labor and National Association of Manufacturers, Dec 1992, Preface.

38. Kennedy, P., Preparing for the Twenty-first Century, New York, Vintage Books, 1993.

39. Porter, Michael E., The Competitive Advantage of Nations, The Free Press, New York, p. 631.

40. Schacht, Wendy H., Manufacturing, Technology and Competitiveness, Congressional Research Service Issue Brief, Congressional Research Service-The Library of Congress, Apr 30, 1993, p. 6.

INDUSTRY STUDY

#2

ADVANCED MATERIALS

TABLE OF CONTENTS

PARTICIPANTS

Students

COL Azumi, Malaysian Army

COL Rusty Moen, USAF

LTC Andre' Barnes, USA

LTC Jim Church, USA

LTC Harry Dutchyshyn, USAF

CDR Tom Hartmann, USN

LTC Bill Hastie, USA

LTC Bruce Hevey, USAF

LTC Walt Lehner, USMC

CDR Jim Maus, USN

LTC Tom Nunn, USA

LTC Steve Opel, USAF

LTC Kathleen M. Spencer, USAF

Ms. A. Lee Battershell, D/AF

Mr. Paul DiRenzo, D/N

Mr. Bruce Hines, D/A

Faculty

Dr. Anthony W. Gray, SES-4

Dr. Robert W. Beckstead

COL Jerry Ball, USAF

PLACES VISITED

Domestic

ARPA	Washington DC
Bechtel Construction Company	San Francisco, CA
Boeing Defense & Space Group	Seattle, WA
Corning	Corning, NY
David Taylor Research Center	Annapolis, MD
Dupont	Newark, DE
Hexcel	Pleasanton, CA
Lockheed Martin Aero-Space	Princeton, NJ
National Institute of Standards	Gaithersburg, MD
NASA Ames Research Center	Moffett Field, CA
Toray Composites	Tacoma, WA
United Defense	San Jose, CA
University of Delaware	Newark, DE
Westinghouse Electric Corp	Baltimore, MD

International Travel

Alenia	Rome, Italy
Fiat AvioTurin, Italy Intermarine SpaLa	Spezia, Italy
Ministry of Research, Science and Technology (MRST)	Rome, Italy
ONERAChatillon, France SAFT	Bordeaux, France
Society of European Propulsion (SEP)	Saint-Medard, France
Society of Fiber Carbon(SOFICAR)	Abidos, France
TAEMA	Rome, Italy

INTRODUCTION

In the 60s, an advanced material signifying the exalted status of its owner was a fiber glass body on a Corvette Stingray. Today advanced materials have evolved to carbon and fiber glass on stealth aircraft and graphite shafted golf clubs. But what are advanced materials and why are they important?

Advanced material describes a broad range of processed or engineered materials that achieve characteristics mandated by their varied users. These materials are categorized as advanced metals, composites, ceramics, and nanostructured materials:

1) **Advanced metals**. Materials that include metallurgically advanced superalloys, specialty steel, and aluminum alloys and powdered metallurgy. Metallurgical characteristics include lighter weight, tougher resiliency, and more environmentally safe materials. The shipbuilding, aircraft, and automobile industries are looking for such characteristics, and powdered metallurgy offers significant benefits to each.

2) **Composites.** Materials that combine reinforcements such as fiber and a binding matrix to maximize performance properties; neither element merges completely with the other. Advanced composites use various types of reinforcement including carbon fibers. Matrices are typically made of polymer, metal, or ceramic.

3) **Ceramics**. Materials that have superior thermal and electrical properties as well as excellent corrosion and erosion resistance. Such materials include alumina, silicon carbide and gallium arsenide. Due to their high thermal expansion coefficients, they are used in products like missile radomes and computer chips.

4) **Nanostructured materials**. Materials constructed on the atomic scale. Multilayered nanocomposites consist of thousands of alternating strata, a few atoms to a few thousand atoms thick. Such materials are sought to produce wear and corrosion-resistant coatings and high strength, low mass engine parts.

The advanced materials industry is a modern, enabling,emerging, and strategic industry. The advanced material industry is modern because it demonstrates all the characteristics and capabilities of a modern industry that effectively uses advances in computer technology to improve design and manufacturing process. It also depends on professionals who design the products of the future and a technically capable workforce. It is an enabling industry that cuts across many economic sectors from research and development to suppliers, processors, and manufacturers to increase performance and efficiency in products and processes. It is an emerging industry developed in response to the need for high- performance weapon systems, that is now emerging in such diverse products as sporting goods, industrial tools,

construction projects, transportation, telecommunications, and computers. It is also hampered by the lack of understanding and acceptance that is normally associated with an emerging industry. This all leads to a strategic industry that can provide higher competitive performance--one that is essential to the growth of the economy.

For purposes of this report we will concentrate on composites, because composites are the materials that are the most mature and will have potentially the largest impact on industries in the 21st century.

INDUSTRY STUDY FOCUS

Our industry study focused primarily on polymer matrix and carbon fiber composites and secondarily on ceramics and advanced metal composites. The former are leading today's industry with regard to new products and substitution for older materials in existing products. Carbon fiber composites appear to have the most potential today because of their characteristics and ease of application.

BACKGROUND

Composite materials are based on the controlled distribution of one or more materials in a continuous matrix to build strength and durability. Each material contributes to the total strength of the component. Plastics are the most common matrix materials, although one can also use metals, ceramics, and intermetallics in a composite matrix. Reinforcements include ceramics, glass, polymers, carbon, and metals formed as filaments, spheres, irregularly shaped particles, short fibers known as whiskers, or flat particles known as flakes.

Composites are as old as nature itself. Wood is a natural composite of cellulose fibers bonded by a matrix of natural polymers, mainly lignin. Early Egyptians reinforced mud with straw to make bricks. Concrete is a ceramic composite in which stones are dispersed among cement. Reinforced concrete is an even better example of a composite. The rebar steel serves as the filament, and the cement forms the matrix. In the 1940s, short glass fibers impregnated with thermosetting resins, known as fiberglass, became the first composite with a plastic matrix.

In a properly designed composite, the reinforcement compensates for low physical properties of the matrix. Furthermore, in many cases synergism enables the reinforcing material to improve properties in the matrix. Composites also offer the capability of placing specific properties where they are needed in the part or component.

The ideal way to develop a product made of composites is to create a model and use a computer program to analyze it extensively before building a prototype. But this is difficult because most computer programs were developed for metals and do

not work well with composites. Many new applications for composites are structural. Since the objective of structural parts generally is to maximize strength-to-weight ratios, a key design objective is to optimize configurations as well as materials.

After the design is defined, manufacturing is the next challenge. Building a single part normally is not the technically challenging phase. The trick comes in developing fabrication processes and techniques for the reliable mass production of composite parts. Unfortunately, the fabrication of composites may also produce built-in defects. For this reason, provisions for nondestructive testing (NDT) should go hand-in-hand with fabrication. Existing NDT methods leave a lot to be desired and are one of many challenges facing composites.

Thermoset matrix systems dominate the composites industry because of their reactive nature and ease of impregnation. They begin in a monomeric or oligomeric state, characterized by very low viscosity. This allows ready impregnation of fibers, complex shapes, and a means of achieving cross-linked networks in the cured part. The early high-performance thermoset-matrix materials were called advanced composites, differentiating them from the glass/polyester composites that were emerging commercially in the 1950s. The "advanced" term has come to denote, to most engineers, a resin-matrix material reinforced with high strength, high-modulus fibers of glass, carbon, aramid, or even boron, usually formed in layers to produce an engineered component. More specifically, the term has come to apply principally to epoxy-resin-matrix materials reinforced with oriented, continuous fibers of carbon or of a combination of carbon and glass fibers, in multi-layered fashion to form extremely rigid, strong structures.

More than 95 percent of thermoset composite parts are based on polyester and epoxy resins; of the two, polyester systems dominate. Other thermoset resins used in reinforced forms are phenolics, silicones, and polyimides. One can mold polyesters using any thermosetting resins process, and can cure polyesters at room temperature and atmospheric pressure, or at temperatures up to 350 degrees F under pressure. These resins offer a balance of low cost; ease of handling; good mechanical, electrical, and chemical properties; and dimensional stability. Epoxies are low-molecular-weight, syrup-like liquids cured with hardeners to crosslinked thermoset structures that are hard and tough. Epoxies have outstanding adhesive properties and are widely used in laminated structures. The cured resins have better resistance than polyesters to solvents and alkalies, but less resistance to acids. Electrical properties, thermal stability (to 550 degrees F in some formulations), and wear resistance are excellent.

Carbon-fiber-reinforced materials, which are two to four times the cost of comparable glass-reinforced thermoplastics, offer the ultimate in tensile strength (to 35,000 psi), stiffness, and other mechanical properties. Compared to the glass reinforced materials these compounds (10-40 percent carbon) have a lower coefficient

of expansion and mold shrinkage, and improved resistance to creep and wear. Strength-to-weight ratios are also higher. Carbon-fiber reinforcement makes plastic compounds partially conductive. In compounds containing small amounts of carbon, this characteristic is useful for applications that cannot tolerate static charges. Applications such as business-machine housings use compounds containing higher percentages of carbon to shield equipment from electromagnetic interference (EMI).

Commercially available structural-carbon fibers are derived either from polyacrylonitrile (PAN) fibers or a special petroleum pitch. PAN-derived fibers, available for several years, are generally selected for high strength. The pitch-based fibers are newer and, while not as strong as the low-modulus PAN fibers, the ease with which one can process the fiber into high-modulus components makes them attractive for stiffness-critical and thermally-sensitive applications.

FUTURE ADVANCES IN COMPOSITES

Several developments point the way to a leaner, more market-oriented, and, ultimately, a more profitable future for the advanced composite industry:

- New process technologies, including a unique pultrusion method that uses resin injection instead of an open bath, and new materials like low-viscosity epoxies for resin transfer molding, are creating new application opportunities for composites.

- Interest in composites is growing in the civil engineering sector. The advanced materials sector is playing a role through the development of polymer concrete and other structural composites.

- New lower cost thermoplastic composite sheets for thermo-forming are poised to make deeper inroads into commercial aircraft and industrial markets.

- Development of non-autoclave curing of composites using microwaves or electron beams promises or offers the possibility of lower cost fabrication.

- Continuous Resin Transfer Molding (CRTM) processes, combine the relatively low cost and simplicity of pultrusion with the benefits of resin transfer molding, including closed resin injection and enhanced reinforcement. This process speeds the production of components that previously required hand layup and autoclaving, and saves an estimated 40 percent in production cost.

WHY COMPOSITES?

Design engineers use composites to meet high performance requirements because they can produce a product with greater strength to weight ratios, fewer catastrophic failures, improved engineering elastic constants, greater resistance to

wear and corrosion, radio frequency transparency, "stealth" properties, and higher thermal conductivity. Engineers can tailor their designs when using composites because manufacturers can "form" composites into the desired shape. Composite components do not have the same physical properties in all directions as more conventional metal materials. These properties in conventional materials inhibit flexibility and design. Using composites, engineers can tailor characteristics and vary the modulus of elasticity, strength, and thickness of a component through design and material choices. Engineers also use composites because of their flexibility in manufacturing. The manufacturing process ranges from fully automated weaving of components from fibers to hand layup of each ply. One can use hand layup as a backup if the automated process fails.

COMPOSITES: WHERE DO WE USE THEM?

Manufacturers use composites in many applications. For example:

Aircraft: Both military and commercial aircraft use composites. "Stealth" aircraft use composites primarily for stealth qualities, light weight, and high strength and stiffness. Commercial aircraft use composites primarily for light weight, high strength, and stiffness. The new Boeing 777 saved 4,100 pounds through the use of composites. Approximately 47,000 pounds of composites were used on the Boeing 777. The empennage is one of the largest single structures made from composites. Although the Boeing 777 uses three times the composites used in the Boeing 757, composites only make up 10 percent of the Boeing 777 total structural weight. Comparatively, both the Airbus A-330 and A-340 use almost 40 percent composites in the structural weight of each aircraft.

Ships: Several shipbuilders manufacture specialty ships using composites. Intermarine in Italy produces a minesweeper with a one-piece hull made from fiberglass. Intermarine uses composites to reduce the ship's signature and vulnerability to mines. Several navies throughout the world, including those from Australia, Malaysia, Nigeria, Italy, and the United States, are procuring these minesweepers.

Land Vehicles: Automobiles and military combat vehicles use composites. Cars use fiberglass bodies and internal combustion engines with ceramic parts to increase efficiency. Armored combat vehicles also use ceramics in "add-on" armor and reactive armor to provide greater survivability. United Defense (formerly FMC) is currently developing a composite armored vehicle (CAV) made entirely of composite materials. The CAV design is a light-weight, air-dropable "armored" vehicle with "add-on" ceramic panels or tiles for increased protection. An added benefit is the composite design provides a reduced signature for the CAV which results in a stealthier vehicle.

Construction: Concrete pillars are lined with composites to prevent deterioration.

Composites are also used for pilings in building piers. Composite structural supports were successful in significantly reducing structural vulnerability to earthquakes. One of the latest uses is in bridges. Composites with carbon fiber reinforcement were used in a covered wooden bridge in Wisconsin. The Advanced Research Project Agency (ARPA) proposed using composites to construct entire bridges.

Bioengineering: Composite valves are used for replacement of defective human heart valves and various prosthetic devices that are in use today. Carbon-based composites are generally compatible with human tissue which reduces the incidence of rejection. In fact, an artificial heart was developed using composites. Doctors are successfully using bone implants using silica-based materials.

Protective Gear: Nomex is a fire resistant composite material developed by DuPont. It is used by both firemen and U.S. military pilots. Gore-Tex is a semi-permeable material used in weather resistant clothing for military personnel, runners, mountain climbers, and fishermen. Composites are also used in nuclear, chemical, and biological resistant suits for the military.

Sporting Goods: The sporting goods industry is the largest user of composite materials today. Composites are used in sporting boats (fiberglass), tennis rackets (carbon), golf clubs (carbon), and fishing rods and reels (carbon). Composites are excellent materials for sporting goods because of their high modulus and high strength-to-weight ratio.

Space: The space program pioneered composite use for many years. In fact, many of the advancements in composite research grew out of the space programs. For example the space program was the first to use composites in nozzles because of their resistance to both heat and wear, and in radomes because of their transparency to radio frequency.

NATURE OF THE INDUSTRY

Overview: The carbon-fiber composite industry consists of four major components: suppliers, processors, manufacturers, and supporting infrastructure. Suppliers provide the basic fibers and resins. Processors weave or arrange fibers to meet the specific engineering requirements of the manufacturers and apply resins. Manufacturers use the resulting materials in a variety of final end products. The supporting infrastructure consists of laboratories focusing on research and development, testing facilities, universities, government agencies, and professional associations. These entities provide the necessary funding and focus on developmental aspects of carbon-fiber composites.

Unlike many other industries, the producers of carbon-fiber composites rely on

relatively few suppliers for raw materials. The number of processors who use the prepared raw materials is larger than the number of basic suppliers. The processors also provide their product to a larger number of varied manufacturers who use composites for such diverse applications as sporting equipment, boats, space systems, construction, and aircraft.

Material Supplies: Material suppliers include a broad range of companies: Hexcel, Soficar, DuPont, SEP, Toray, AKZO, Hercules, AMOCO, Toho, US HisPan, and Ciba-Geigy. These companies range from single-product producers like Soficar and US HISPAN, to multi-dimensional firms like DuPont and Hercules. Also of note, several firms (such as SEP, Hexcel, and Hercules) are vertically integrated throughout the entire process, others are partially vertically integrated such as Toray and AMOCO. Significantly, Toray and Toho, both Japanese firms, control approximately 48% of the global carbon-fiber market. Furthermore, Soficar is a joint-venture of Toray in Japan and ELF in France, while AMOCO in the U.S. is a licensed producer of Toray carbon-fiber products. A majority interest of AKZO's fiber division is owned by Toho. It is apparent that control of carbon fiber on a global basis is centered in or controlled from Japan.

Material Processors: Material processors include: Hexcel, Toray, SEP, Fiberite, Ciba-Geigy, Hercules, and Cytec. Consolidation of material suppliers to a relatively few sources has taken place, yet prepreg producers reflect a larger number with smaller individual market shares. Therefore, this industry shows a greater dispersion at the processor level on a world-wide basis.

Component and Systems Manufacturers: The principal users of carbon fiber composite materials vary widely. Manufacturers as diverse as Boeing, Bechtel, Lockheed, SEP, Alenia, Airbus, Fenwick, and Wilson span the gamut of simple to sophisticated applications. Carbon fiber and resins engineered to meet exacting specifications in the aviation and space industries reflect the results of advanced stages of research and development, while the production of fishing poles and tennis rackets rely on proven performance of past technological innovations.

Asia used 45 percent of the world's carbon fiber in 1993. This generally reflects the low end of the technological scale with Asian manufacturers concentrating on sports equipment and applications outside advanced areas such as space and aviation. North America and Europe are home to the more advanced technological uses of carbon fiber composites and parallel the nature of the industries and research facilities found there.

Supporting Infrastructure: Laboratories, testing facilities, universities, government agencies, and associations all provide an underlying structure for the industry at large. Both government and industry recognize that low-end technological applications, such as sporting equipment, find easy access to the market because of the performance

advantages they offer over contemporary materials, while high technology composites applications find barriers based on lack of knowledge among engineers and consumers. In response the supporting infrastructure not only disseminates information concerning advanced materials, but also promotes research and development. For example, the government finances research and development and in many cases provides the requirements for specific state-of-the-art composites that stimulates development and acceptance into the market. American universities are increasingly beginning to educate advanced materials engineers thereby helping to provide the manpower for future development and utilization of composites.

HEALTH OF THE INDUSTRY

Overall: The United States has emerged as the only remaining global super power after the Cold War. This status is the result of several factors. One main factor is its technological superiority. As a result, the United States is a great exporter of technology. In many cases, the United States is characterized as the world leader in various technological areas such as medicine, manufacturing, and automation. Also, because of the United States' expertise in high temperature epoxies and resins, it was able to maintain a technical edge in aerospace applications. The high demand by automotive and marine users of glass fibers helped the United States maintain its position as a global supplier, but the United States does not, by any means, dominate the entire market. For example, in the broad area of composite technologies, Japan is leading in four of six areas reflected in the 1993 Department of Commerce study. This occurred in large part because of the declining number of U.S. firms in specific markets due to reduced defense budgets/contracts, not because the U.S. industry lacked expertise.

The United States Government is trying to counter the eroding industrial base through several initiatives that include financial investment in materials research and development. This effort enables the different departments (i.e., Department of Defense, Department of Commerce, etc.) to achieve individual goals and retain U.S. knowledge and expertise that will allow it to continue as a leader in the international marketplace.

The U.S. Government understands that the nation's infrastructure, economy, military, and environmental well-being are linked to the development of advanced materials and their associated technologies. The benefits from development of advance materials and associated technologies will carry the nation into the next century.

Even though the fiscal year 1994 Federal Budget Research and development investment is approximately $2 billion for seven areas (i.e., health, energy, defense, environment, infrastructure, transportation and information/communications), industry needs continued improvements in advanced materials, associated manufacturing

processes, cost reduction of the final end products, and customer product acceptance.

Many industries are starting to increase their use of automation as a means to reduce the high cost of labor associated with several advance material manufacturing

a large up-front capital expenditure, it will yield better efficiency and a lower product cost in the long run. Additionally, industries are looking at composite materials to replace tools or manufacturing components that deteriorate from high heating rates and corrosive environments. The longer these elements last, the less costly the end product.

Even though the use of advanced materials is on a steady climb, which attests to the fact that the health of the industry is constantly improving, there are still barriers to overcome. One constant barrier is the reluctance or hesitation to readily include advance materials as a first choice or as a better product in either new or upgraded systems. The advanced materials industry still has to prove that its product is just as strong or stronger, more flexible, as reliable, and "stealthier" than more conventional materials. Many engineers and designers are waiting for the experience factors to accumulate or for someone else to try the product first before they use or fully accept the new material.

Producers: The effect of reductions in defense expenditures and the global economic slowdown is reflected in ongoing consolidation in the advanced materials industry. Each segment of this industry evolved somewhat differently. One can classify the basic material suppliers segment as mature.

Because of the decline in demand, an oversupply seems to exist. This apparent oversupply resulted in a decline in the numbers of producers. Major companies cannot afford to maintain less than profitable units and are either selling these units or closing the doors. In a FY94 Department of Commerce study more than half of the facilities surveyed reported that they were using less than 50 percent of capacity.

The remaining material suppliers of precursors, fibers, and matrix material (resins) are located in the United States, Japan, and Europe. The Japanese took the lead in the development of carbon fiber and influenced consolidation of the industry by controlling nearly 60 percent of carbon fiber production.

The material processor portion of the industry is also consolidating. However, unlike the material suppliers, the material processors are generally located near their customers rather than geographically located in any one area.

Design Tools: The application of design tools is somewhat fragmented. Advances in computer technology improved the way engineers model product designs and

manufacturing. Modern computer "based" design programs, such as CATIA, are used in designing aircraft, but lack the necessary subroutines or tools to help engineers integrate advanced materials into these designs.

The industry needs to augment these tools with more powerful tools that can address the very specific properties of specific composites. New computer subroutines or design tools are just beginning to give engineers what they need to factor in options ranging from the type of composite used to the orientation and internal structure of the material, all critical to optimizing composite and final product design.

Proprietary interests inhibit the flow of information exchange for the development of computer design tools and standards. Companies see this industry as highly competitive and are very reluctant to release the specifics of processes that protect their position in what they perceive as a series of niche markets.

Manufacturing: The manufacturing portion of the industry is more mature. Component manufacturing processes are moving away from the high labor content in traditional manual layup techniques to more automated production using automated tape machines and other advanced manufacturing tools.

As this industry becomes more competitive, the manufacturers' demand for consistency has resulted in improved quality in basic materials. When combined with more automated manufacturing techniques, these processes are producing more reliable products with less variation in their performance. Additionally, more sophisticated in-process inspection techniques, such as ultra-sound and improved computer mapping techniques, are helping the industry detect, correct, and eliminate structural defects such as voids or substandard bonding.

Unfortunately, a major drawback for entry and continued presence in this market is the high capital investment. It costs millions to purchase the facilities and tools that include numerically controlled, multi-axis cutting machines or layup tools; high temperature, high pressure autoclave ovens for curing; and exotic forms and molds.

Repair of Composites: The technology to provide adequate maintenance and repair of composites is immature. As opposed to metals, the complex structure of composites pose questions with respect to crack propagation and delamination. The industry needs to develop simpler detection and repair procedures.

ISSUES

There are several key issues which have impacted the emergence of advanced

materials as substitutes for traditional materials. These include: performance requirements, life cycle costs, cost barriers to entry into the industry, insufficient design standards/knowledge base, and inconsistent government policies/initiatives. In addition, government must consider the promotion of advanced materials through industrial policy, incentives, and direct funding.

Performance: The key characteristic, and probably the most positive influence on the use of an advanced material versus a traditional one in most applications, is performance. Time and again throughout our study, we saw that the most significant driver behind the use of an advanced material or composite was a desired level of performance not attainable with a traditional material. NASA and the DoD have funded technology "pull" programs which produced materials for specific applications that were lighter, stronger, stiffer, more temperature resistant and stealthier than traditional materials. Other than the current need for stealthiness, weight and strength were probably the most sought after significant performance characteristics of advanced materials. Graphite-epoxy composites used in high-performance aircraft and Kevlar used in bullet-proof vests and Army helmets are examples where stronger advanced materials have replaced traditional materials, and at lighter weights. Durability, resistance to corrosion, and inert electromagnetic qualities are other positive performance factors which fostered the use of advanced materials. While these materials provided significant increases in performance over traditional materials, it was not without costs.

Life-cycle Costs: In general, the use of advanced materials as a substitute for traditional ones was slowed by higher costs. The use of traditional materials in high-production situations was relatively inexpensive (steel at less than $1.50/pound in automotive applications) compared to advanced materials (up to $300/lb for composites in aerospace applications).[1] More and more, however, the use of advanced materials is making its way into higher production rates such as in the semiconductor industry, sporting goods, or in the small watercraft industry. In each advanced material application, industry performs cost-benefit analyses to determine if the performance, capability (e.g., stealth), producability, and maintainability justify the cost. In the DoD and NASA where performance requirements were pushing the envelope, the higher costs associated with advanced materials were more easily justified and use of advanced materials progressed more quickly than in the commercial world. For instance, modern combat aircraft use 35 to 50 percent composites, while the newest airliners still in development have only reached an 8 to 12 percent composite level.[2] While an increase in composites would certainly increase performance and save weight in civil aircraft application, the increased performance did not justify the increased development and production costs. These high material costs are related to several factors throughout the life cycle of the system such as material production, inspection, and maintenance.

Producibility: Producibility in terms of composite materials presents a new set of

problems to manufacturers. The typical layup processes one often thinks about when working with fiberglass-type composites are not technically difficult but can be time consuming. High strength composites often require high temperature and/or pressure curing in their manufacturing processes. Inspection of the material during the manufacturing process also requires a different approach than that of traditional materials. These time consuming and apparently inefficient processes kept the costs of composite manufacturing relatively high and subsequently hindered the substitution of advanced materials for traditional ones. However, government, academia, and industry are all working to improve these processes. While visiting the National Institute of Standards and Technology and the University of Delaware, we observed work aimed at improving the liquid injection molding process. Using modeling and simulation to predict mold filling dynamics, the engineers were able to design molds and processes which will maximize the consistency of part saturation and increase overall production yield. Another important challenge in the manufacturing process that the University of Delaware officials addressed was in-process inspection of materials. They proposed systems which evaluate materials in real time during the production process so workers can alter the actual production process in real time to compensate for an impending defect and again increase effective production yield. As this technology matures, industry will benefit from reduced material costs and the world will see increased use of advanced materials.

Maintainability: Maintainability of advanced materials or composites is a good news or bad news story, depending on the application. Composites are excellent materials for marine applications such as piers, docks, and wharves due to their resistance to corrosion, thermal cycling, parasites, and other marine environmental forces.[3] If structural damage to a composite component occurs, repairs can range from simple to complex depending on the application. One of the major costs associated with the introduction of composites into the civil aircraft environment is component repair. While traditional metal alloy parts were resistant to major damage and fairly easy to repair, composites are exactly the opposite. While damage from a lightning strike on a conventional component might produce a few burned rivets that are easily repaired, a composite component will typically either show no damage or require extensive repair or even replacement. In fact, because many major airlines are poorly prepared to deal with the new technology of composite repair, they send damaged components out to repair facilities which specialize in the composite component repair business. These repair facilities stock the many varieties of prepreg and resins necessary for repair which are often cost prohibitive for individual airlines to keep in inventory. Clearly, the increased use of composites in aerospace is not without a corresponding cost for maintenance.

Cost Barriers to Entry: In addition to the product life-cycle costs associated with composites or advanced materials, there are also other cost barriers that restrict the growth of the industry. Among the major cost barriers are costs to certify products

and processes and costs of capitalization. Globally, companies are embracing quality standards that include the ISO 9000 processes which require strict certifications. For example, the ISO 9000 certification requires close control during the fiber and resin manufacturing processes so the desired end product will emerge. If workers cook a fiber a little too long or at too high a temperature, the producer may end up with a pile of charcoal dust at the end of the production line! If workers do not mix resins properly and control temperatures very carefully throughout their production cycle, the resins are ruined or certainly not within the desired specifications. In the prepreg process, a great deal of machinery is required to weave the materials and impregnate the fabrics with resin. Once again, key components of that machinery are control systems to keep the processes within acceptable bounds. Finally, in the end-product manufacturing process, automated tape laying machines, pultrusion machines, and autoclaves are all key capital investments of a modern composite manufacturing facility. This equipment is very expensive and is typically only used for one thing. As one can see, there is a great deal of capital investment involved in getting into the composites business, either as a producer or user. Until costs are reduced or profitable economies of scale are reached, cost will remain a barrier to entry.

Design Standards/Knowledge Base: The design standards and failure characteristics of traditional materials are well documented and understood in major industries such as aerospace, automotive, and civil engineering. In terms of advanced materials, the knowledge base is much smaller. As a result, engineers have a natural tendency not to use an advanced material unless absolutely necessary. In small niches such as the high-performance aircraft business, progress is made as a matter of necessity. In civil aviation applications, however, the industry is moving much slower towards composites. An area which holds great potential for conversion to advanced materials is in civil engineering. With the significant rebuilding of the national highway and bridge infrastructure that is required in the coming years, it seems that composites would be a great solution for many material applications. The industry, however, continues to stress in trade periodicals[4] that the use of composite materials is hindered by the lack of established design standards handbooks on advanced materials, and general education within the industry's engineer community. Government and university research programs are addressing this problem. For example, the University of Delaware's Center for Composite Materials is developing design standards and more cost efficient production, evaluation, inspection, and repair processes. A key element in developing design standards is to gain a reasonable understanding of the fatigue and failure characteristics of these advanced materials. In many cases it is easy to design conservatively, minimizing the impact of fatigue and failure. However, to gain the most efficiency from advanced materials in terms of cost and performance, the designers must have confidence in the durability and performance of these elements. Once this data is derived and distributed to the design communities we should see an increase in the use of advanced materials and a decrease in costs associated with over-design.

Government Support: While previously discussed factors were related to the materials themselves, this issue relates to government support for the industry and its associated technology. Over the last several years the US Government took several initiatives to promote research, development, and application of advanced materials in this country. These initiatives included policy development and direct funding to universities and industry for advanced materials related projects. Policy initiatives such as the National Advanced Materials Initiative of the 1992 Energy Policy Act were aimed at efforts to "foster the commercialization of techniques for processing, synthesizing, fabricating and manufacturing advanced materials and associated components."[5] In addition, President Clinton sponsored the Advanced Materials and Processing Program during the FY 93 and FY 94 budget cycles. The objective of this program was to "bridge the gap between innovation and application of advanced materials technologies." In terms of direct funding the Government followed several avenues. For example, the University of Delaware's Center for Composite Materials is performing government work through the US Army Research Office's "University Research Initiative Program." In addition the university receives funding through several grants that the Advanced Research Projects Agency (ARPA) "Technology Reinvestment Program" awarded. On the industry side, the government is funding both individual companies and consortia for materials application projects through Cooperative Research and Development Agreements (CRADAs). While industry is excited about the progress and initiative CRADAs foster, they worry about the impact of budget cuts on these programs and whether or not industry can sustain the momentum when government funding declines.

IMPACTS ON NATIONAL SECURITY AND MOBILIZATION

Relevance: First, the performance gains available from advanced materials will remain relevant well into the future. Performance gains include faster, more efficient, lethal, or survivable weapon systems or maybe even lighter more transportable or repairable support systems. Each has important implications for American's ability to field a more capable force despite a smaller overall force structure. Advanced materials when used correctly are a force multiplier.

Access: To gain higher performance, engineers and manufactures must have access to the basic materials needed for producing carbon fibers and matrix material. Currently these materials are in abundant supply. In fact, much of the industry consolidation was attributed to the abundance of material on today's market that caused prices to drop and drive out many small suppliers who could not survive on small profit margins. However, if the forecast growth in the demand of carbon fiber is only half right, America can find itself facing a shortage such as the computer industry is currently experiencing with silicon wafers.

A representative from one of America's major suppliers of defense electronics said that in the past, they could get silicon wafers used in computer chips within

weeks and sometimes days. Today, however, with the huge global demand from the commercial sector, his company must order months in advance to guarantee the supply of silicon wafers for their military applications. While the fierce competition for these wafers caused prices to fall, low prices also forced smaller, less efficient companies to close which resulted in consolidation of the domestic industry. The shrinking industrial base coupled with commercial requirements keeps the industry's supply and demand in balance. However, the more critically balanced the industry is the less likely we will have surge capability for a large growth in demand.

Like the silicon wafer story, if the demand for carbon fiber grows too quickly, U.S. could find itself in a situation that rapidly turns from overabundance to a critical shortfall. In a war-time mobilization U.S. would probably prioritize the use of these materials to support the war effort. However, as during World War II, materials needed for the war effort were often the same materials needed by many different industries to generate the weapons of war. This cross-cutting nature of the materials industry reduces prioritization to a difficult dilemma.

<u>Cost of Domestic Sources</u>: One way to help control defense-critical materials is to make sure the DoD of the U.S. has adequate control over the source of supply. As today's world moves to more global markets, it does not require much imagination to develop a scenario where national priorities will not necessarily mesh with those of a global company. If a company controls a critical resource, this could result in excessive leverage over national policy.

For the United States to assure it can retain domestic access in the carbon fiber industry, it must require that the complete "food chain"--from precursor to end product--remain available within the United States. However, because of the efficiency of huge Japanese suppliers and the inefficiencies of small U.S. suppliers, the U.S. costs are higher. The result--US producers lose world market share. Couple these higher prices and current DOD policies demanding U.S. content in defense weapons and it is easy to understand why the cost of U.S. weapon systems soar upward. Maintaining this capability will continue to be an expensive proposition until U.S. firms become more efficient and demand recovers so U.S. producers can operate more cost effectively.

<u>Process Constraints</u>: Even domestic access to the raw materials does not guarantee that the industry can surge to meet mobilization requirements. Sensitive processes, costly tooling, and stringent environmental regulations present formidable barriers to both new players who are trying to enter the market and to established players trying to qualify new products. One of the companies we visited, an established leader in the industry, spent more than two years and over $45 million just to locate a processing plant to make prepreg in the U.S. The time and cost of putting in a carbon fiber production facility represented additional costs. When the Environmental Protection Agency (EPA) shut down the only source within the U.S. of

rayon fiber used as the precursor for carbon fibers used in U.S. rocket nozzles, it took four years and cost almost $22 million to qualify a new source. The EPA closed the facility because of water pollution problems caused as a result of the caustic by-products from the rayon production process. Because the US Air Force and NASA had to have a domestic source for the rayon precursor material, these agencies had to find and qualify a new source in the United States. The Air Force and NASA had to requalify all components that used the new precursor. The requalification process included at least eight different firings of large solid propellant engines.

A mobilization effort that tries to generate advanced materials or composites from a standing start would certainly take longer and require more investment. The production facilities required for composite materials are unique in physical layout and hardware requirements, and are better built from scratch than trying to modify traditional facilities. For example, one major airframer built an entirely new production facility to accommodate the size of the composite components and the unique manufacturing processes in an attempt to begin the U.S. optimizing the composite production process. Until increases the use of advanced materials throughout industry and builds the necessary associated facilities, existing outmoded facilities and production plants will constrain mobilization efforts.

Education: The key to our future success lies with the American education system. The U.S. university system has a reputation as the best in the world and continues to draw students from around the world. By promoting education in advanced materials we lay down the foundations for innovations in materials and applications that can fully exploit the potential of advanced materials--not just for U.S. domestic markets.

We visited a local university, a noted national center of excellence in composite materials. We listened as a graduate student (from New Zealand) briefed his advisor (from India) on the effects of mold gaps on permeability during resin transfer molding, a high interest area in modeling the materials manufacturing process. This visit showed us not only how the American education system promotes the use of composites but also helped us understand the openness of our education system. While these foundation technologies promoted the growth of technology, the system also promoted the flow of technology. The American education system helps domestic and international engineers understand the capabilities and limits of advanced materials--and this knowledge base must be expanded.

Some may regard this transfer of technology as a threat. But when these students continue their materials research at other universities and industries around the world, they create a network of colleagues that can broaden the technical base for industry. This base will create competition, but will also produce the innovation necessary to exploit the technologies.

The United States ability to meet future threats will depend on how well it meets future challenges. By promoting advanced materials in our education system, the U.S. can produce the engineers and skilled labor necessary to design and produce the innovative products, equipment, and processes key to the growth of the industry and the economy--not from just a domestic market but rather from a wider international knowledge base as well.

High Tech Drivers: Until commercial activity increases in the broad industrial sectors such as transportation and construction, the high-tech applications will continue to drive the industry until increased volume drives down prices. Defense needs thrive on the high performance capabilities achieved through advanced materials; therefore, we can expect defense consumption will have a direct impact on the process technology as well.

This link formed the core strategy for one of the companies we studied--even in the sharply declining world-wide defense markets. They reasoned that defense business would not only keep pace with the materials used, but also provide risk reduction opportunities for developing supporting application processes. Once the processes were in place, the company could apply the techniques to exploit commercial spin-offs.

Mobilization planners need to recognize that the advanced material companies still need investment. When and if we breach the cost barriers to commercialization and see the increased demand projected, then perhaps the industrial incentives from defense could be reduced and defense industries could leverage off the commercial market for further military applications. However, defense must have priority in production if an emergency arises. Even though defense may only be five percent of the market in the future, the criticality of advanced materials in future systems will certainly justify its priority.

RECOMMENDATIONS

The US Government must continue to promote and fund research and development and demonstration programs, and not just for the "high-tech" segment of the industry. Transportation, construction, and broad based industrial applications such as the San Diego bridge project all look to the Federal Government for partnership to reduce the risk, build the confidence necessary to broaden the industrial applications, and improve manufacturing techniques. By building this confidence, we increase demand and hopefully drive down prices due to the increased volume and competition resulting from increased use. The DoD can leverage this new commercial capacity and apply advanced materials to many other segments of tomorrow's force structure.

In order to fully realize the potential benefits of increased government and industry partnerships, and the resulting technology transfer, the Federal Government must continue to fund and streamline programs such as the cooperative research and development agreements (CRADA) which incentivize industry participation in government research programs. Government laboratories and commercial companies operate by different criteria and paradigms, and problem areas still exist over issues of intellectual property rights, licensing, publication rights, liability, and public access to CRADA data. Delays which are commonplace to government projects are not viewed so generously by commercial companies.

The U.S. Government must address the issues of proprietary rights and lack of standardization that constrain industrial growth. Today's companies jealously guard their product specifications and processes in order to preserve their share of the market. This is easily justified to the many companies who rely on technological innovation to "lead" their competition, innovation whose sole purpose is to convert ideas into dollars. This area will require cooperation and collaboration--a true partnering with industry to help design policy and law that can protect intellectual ownership as well as push industry to a set of design and material standards. By confronting these issues of ownership and standards, we should be able to promote information diffusion that can lead to improved databases on material characteristics and processes, and eventually generate the proliferation of advanced materials technology.

The Government must take the lead in making this happen through a stable, long-term commitment to funding of materials research and development, and stabilizing the ever changing Congressional legislation that redirects funds and agency responsibilities each year. Stable funding for such agencies as the National Science Foundation and National Institute of Standards & Technology is critical if we are to make the "leapfrog" improvements possible through prototyping and demonstration programs and precompetitive consortia of industry, academia, and government laboratories. As defense industries downsize and consolidate because of greatly reduced procurement budgets, the government needs to look at revising its anti-trust legislation to allow this consolidation of producers to take place.

The need for improved educational programs echoed from every company and agency. European, U.S., and even Japanese representatives highlighted shortfalls, with each feeling a need to bridge the cultural gap to bring educational systems and industrial users closer together. Whether through cooperative research programs or U.S. influence on certification programs, U.S. government agencies need to encourage universities to broaden their student's exposure to advanced materials options in core engineering programs. This emphasis on the engineering level will enable the insertion of advanced materials into new systems. These insertions will increase the demand both for existing advanced materials and new ones. Also, the increase in usage of advanced materials will spark advances in manufacturing and create new

types of laborers who will require more advanced technical training. We need to highlight national centers of excellence that maintain close ties with the needs of industry, because this consortium of industry, government, and universities holds some of the greatest promise for the rapid advances in breakthrough technologies in advanced materials. Technologies do not stand alone; process technologies and integration are also needed. This can best be accomplished by government, industry, and academia working together. It may be the only way for the U.S. to stay ahead of our foreign competition in systems developments which capitalize on the use of advanced materials and brings them to the market place.

END NOTES

1. Interview, DuPont Advanced Materials Inc., Mar 17, 1995.

2. "Tomorrow's Biotech", Forbes, Mar 29, 1993, pg.77.

3. "Marine Structures", Modern Plastics, June 92, pp. 91-93.

4. "Questioning Composites", Civil Engineering, Jan 93, pp. 64-65.

5. Federal Register, Vol.58, No.103, Jun 93, p. 31199.

DECEMBER 1995
ICAF- FAS ANNUAL LEAVE & TDY SCHEDULE
(As of DEC 8 '95)

SUNDAY	MONDAY	TUESDAY	WENDESDAY	THURSDAY	FRIDAY	SATURDAY
					1 Kovner: SL Weathers: AL	2
3	4 Gropman: TDY, AL McGee: AL	5 McGee: AL	6	7 Weathers: AL	8 Weathers: AL	9
10	11 McGee: AL	12 McGee: AL Starron: TDY, HI	13 Starron: TDY, HI Crahan: TDY, R.I.	14 Starron: TDY, HI Crahan: TDY, R.I. Weathers: AL	15 Starron: TDY, HI Crahan: TDY, R.I. Weathers: AL	16
17	18 Gropman, Toth: AL	19 Gropman, Toth: AL	20 Hoskey,Toth Robinson: AL	21 Hoskey,Toth Robinson: AL	22 Hoskey,Toth Robinson,Moss: AL	23
24	25 **PUBLIC HOLIDAY**	26 Hoskey, Toth Weathers, Rajapakse,Moss: AL	27 Hoskey,Toth Weathers, Rajapakse,Moss: AL	28 Hoskey,Toth Rajapakse,Moss: AL	29 Hoskey,Toth Weathers, Rajapakse,Moss: AL	30
31 Hoskey: AL						

INDUSTRY STUDY

#3

AGRIBUSINESS

TABLE OF CONTENTS

PARTICIPANTS

Students

CAPT Allan A. Banghart, USN

Mr. Julian L. Bartley, State Department

LTC Paul D. Bransford, USA

Mr. David L. Ferris, D/N

LTC David F. Goold, USMC

LTC Norman B. Hodges, USA

CDR Ernesto Juan, Argentine Navy

Ms. Carmen M. Martinez, State Department

LTC John A. Marx, USA

CDR Laurie A. McKee, USN

Ms. Mary C. Miller, D/N

Mr. Bruce L. Ramsey, Department of Agriculture

COL James R. Stordahl, USA

LTC Donald G. Tucker, USA

LTC William C. Walker, USAF

Ms. Barbara A. Westgate, D/AF

Faculty

Mr. J. Dawson Ahalt, USDA

COL John Grabfelder, USAR

PLACES VISITED

Domestic

Domino Sugar Corporation	Baltimore, MD
Countrymark Cooperative, Inc.	Baltimore, MD
Agricultural Research Service (USDA)	Beltsville, MD
University of California	Davis, CA
CALGENE	Davis, CA
California Farm Bureau Federation	Sacramento, CA
Department of Food and Agriculture	Sacramento, CA
California Rice Industry Association	Sacramento, CA
Matthews Rice Cooperative	Marysville, CA
California Canning Peach Association	Lafayette, CA
Dan and Jeff Stephens' Peach Orchard	Yuba City, CA
Agricultural Council of California	Sacramento, CA
California Cattlemen's Association	Sacramento, CA
Blue Diamond Growers	Sacramento, CA
Kautz Farms	Lodi, CA
Victoria Island Farms	Holt, CA
Western United Dairymen	Modesto, CA
The Durrer Dairy Farm	Modesto, CA
Oakville Experimental Station	Oakville, CA
St. Supery Winery	Rutherford, CA
Joseph Phelps Vineyards	St. Helena, CA
Chicago Board of Trade	Chicago, IL
Chicago Mercantile Exchange	Chicago, IL
Chicago Board Options Exchange	Chicago, IL
United States Department of Agriculture	Washington D.C.
Wampler-Longacre	Broadway, VA

International

Danone Group	Paris, France
Centre d'Etudes et de Recherches du l'Armee	Paris, France
Societe UCL Cheese Cooperative	Isigny sur Merr, France
Rungis Merche International	Rungis Cedex, France
Haut Fonctionaire de Defense	Paris, France
Food and Agricultural Organization	Rome, Italy
World Food Program	Rome, Italy
SRL Cheese Processing Plant	Sezze, Italy
Giuseppe Water Buffalo Farm	Sezze, Italy
Fontana di Papa	Cecchina, Italy
United States Embassy	Madrid, Spain

Spanish Minister of Agriculture	Madrid, Spain
Cooperative de Aceite	Villarejo de Salvanes, Spain
Bodegas Ricardo Benito	Navalcarnero, Spain
Grupo Navidul, S.A.C.	Madrid, Spain

INTRODUCTION AND OVERVIEW

This report details the role and significance of the U.S. agribusiness industry as an element of America's industrial base, reviews its contribution to the nation's economic strength, and evaluates its position among its global partners. We begin by establishing the strong linkage between agribusiness and U.S. national security. The structure, conduct, and performance of the industry is then analyzed and compared to the agribusiness industry of the European Union. Finally we analyze the proper role of the federal government in managing this strategic sector of the economy and provide recommendations regarding the future direction of U.S. agribusiness.

AGRIBUSINESS AND U.S. NATIONAL SECURITY

America's agribusiness industry has been, and will continue to be, an essential element of this nation's economic and political power, as well as an important factor in the use of our military force. This industry's contributions to the development of the nation's resource base has afforded America the ability to sustain a level of international preeminence unmatched by any other country in the 20th century. Agribusiness is of critical strategic importance to our current and long term national security interests. A quick review of some key facts and figures captures the essence of the role agribusiness plays in U.S. national security.

Economic Power: In aggregate, the U.S. agribusiness industry now contributes approximately 17 percent of America's Gross Domestic Product (GDP), 14 percent of its total exports, and about 18 percent of the nation's jobs (some 21 million). With a record of more than 30 consecutive years of significant trade surpluses, and with no end in sight, agribusiness has been the perennial star in America's struggle to achieve and sustain a respectable balance of trade. While the sheer size of American agribusiness makes it a formidable force in the global market place, its real strength is in its efficiency, not its mass.

With less than seven percent of the earth's land and only five percent of the global population, America produces more than 12 percent of the world's food. The U.S. dedicates only two percent of its population to the production of food and spends less than 11 percent of its after-tax income to feed itself and support a thriving import/export surplus. By contrast, the European Union (America's strongest agribusiness competitor) dedicates almost five percent of its population to the production of food and 21 percent of its disposable income to feed itself.

American agribusiness' immense contributions to the U.S. economy come with relatively little pressure on America's land, human capital, or financial resources. This situation provides the U.S. a profound strategic advantage in its effort to sustain its position of global economic leadership. The valuable land, labor, and dollars NOT going into American agribusiness are free to contribute to other areas of the economy.

U.S. agribusiness' low profile may be its greatest contribution--and possibly its greatest weakness. America must not lose track of the role agribusiness plays in the economy merely because it is not today's "squeaky wheel."

Political Power: Agribusiness appears to be taking on an ever-increasing role in the use of U.S. political power. Possibly the greatest key to ensuring America's national security is its reliable, abundant food supply--more than "just enough" to feed Americans. The ability to reliably produce large exportable food surpluses every year represents a powerful instrument of national power for the future. Not only does it ensure this country remains self-reliant, it also serves as a means to encourage favorable behavior from other nation-states. Because we can literally "feed the hungry" of the world, U.S. grown and processed food has already become an important aid to influence free market economic and democratic political development in countries around the world. As the world population growth continues to advance, reaching a projected 10 billion by the year 2030, U.S. food will become even more important in preventing civil wars and border clashes over limited food-producing land, and in preventing mass migration of starving populations.

Military Power: The military forces of the U.S. and her allies are obviously consumers of U.S. agribusiness products, primarily food and textiles. However, we will not make the claim that agribusiness is a "defense" industry. It is not! While American men and women in combat will always need to eat, we cannot envision any future conflict in which the United States might engage wherein domestic agribusiness productivity becomes a constraint on operations. The changing nature of war and state-of-the-art food packaging and delivery capabilities make adequate troop support in the future a virtual certainty. American military forces in the 21st century will not--unlike Napoleon's armies--travel on their stomachs.

The collapse of the Soviet Union and Eastern bloc has dramatically increased the relationship between agribusiness and the exercise of military power. America's foreign policy focus has shifted from containing the "Red Menace" to engagement and enlargement. Food, as discussed briefly above, will be one of America's key foreign policy tools and the U.S. military will often be the instrument which helps deliver or ensures the delivery of food in emergency situations.

Many military planners have been pondering the future employment of U.S. military forces. Agencies such as the United Nation's World Food Program are very clear about the major role they envision U.S. armed forces playing in the war against hunger. They believe that only the U.S. military can bring the communications capabilities, logistics infrastructure, and forceful security "presence" required to ensure the emergency delivery and continuous availability of food anywhere on the planet--at a moment's notice. United Nations' agencies perform reasonably well in providing long term support for feeding programs. However, the U.N. does not have the resources to rapidly respond to crisis situations, nor does it possess the legal mandate

to act decisively in politically or militarily difficult situations.

The probability that major regional conflicts or crises will continue to arise as a result of hunger or starvation is extremely high and not likely to subside in the foreseeable future. The dire effects of poverty are localized hunger, malnourishment, and starvation. Current estimates of the world's chronically malnourished, hungry, and starving range from 800 million to 950 million. Areas of the most severe poverty and hunger are also hindered by a lack of infrastructure (nonexistent roads, inadequate communications, etc.) and people living outside the economic mainstream. America will be directly involved in the resolution of the conflicts and crises that result from this pervasive poverty. This involvement will include providing of U.S. agribusiness products, financial support, infrastructure, and possible military intervention.

Recent crises in Somalia, Rwanda, Haiti, and Bosnia all shared a common denominator: the threat of widespread hunger and starvation. In the future, U.S. military involvement in wars and "operations other than war" will, more often than not, involve the restoration of a continuous supply of food and building an infrastructure to sustain it. The changing global political-military environment and the U.S. military's unique capabilities will ensure that U.S. military operations and world-wide agribusiness developments remain closely linked. The U.S. military and American policy makers must stay tuned to the status of trends and issues in this truly strategic industry.

STRUCTURE AND CONDUCT OF U.S. AGRIBUSINESS

Agribusiness includes all functions associated with the production, processing, distribution, and consumption of food and fiber-from the upstream suppliers to the final consumers. This includes: farm supplies, farm production, imports, exports, food assembly and processing, wholesale and company sales forces and food brokers, retail outlets, and institutions. Food is the very fabric of our lives. U.S. agribusiness is nearly a three-quarter **TRILLION** dollar industry, representing 17 percent of the GDP. According to United States Department of Agriculture's (USDA) *Agricultural Trade Highlights*, the U.S. is projected to export a record $48.5 billion worth of agribusiness goods in 1995. U.S. agriculture or agribusiness is highly competitive with numerous firms involved in every facet of business activity. The U.S. has the most open market structure in the world with effectively no barriers to producer entry.

U.S. agribusiness is characterized by five noteworthy factors:

(1)The business is highly integrated, both vertically and horizontally. Vertical integration occurs when, for example, one company controls feed ingredients, breeding, slaughter, processing, packaging, distribution, transportation, and rendering of by-products. Today, almost one fifth of farm output is under contract to, or produced by, vertically integrated operations. Horizontal integration occurs when related industries are incorporated into companies such as processing, advertising,

farm supplies, and fuel production.

(2) Prices are set primarily by competitive market conditions due to the large number of buyers and sellers.

(3) Production is highly technical. The agriculture industry has experienced dramatically increased production throughout this century, largely through technology and its associated advances. Today, technology is expanding to provide quality improvements in products, reducing water, soil and nutrient requirements, and increasing crop and animal resistance to disease.

(4) Information technology base is highly developed. The information technology base includes crop and livestock data and timely market, financial, and weather information which are automatically transmitted globally.

(5) Finally, and contrary to popular belief, its jobs require highly specialized skills and abilities. The modern farmer not only sits on a tractor; but also uses a computer terminal and applies sophisticated processes in the production and marketing of agricultural goods.

Producers and Processors

The recent trend toward consolidation continues throughout the industry. The average size of a U.S. farm is increasing and is now 480 acres. The days of the small family farm are rapidly becoming a thing of the past. Consolidation has led to higher efficiency, decreased costs, and increased output. Today there are over 800,000 commercial farms in the U.S., however only 300,000 of them produce 85 percent of the U.S. agricultural output.

In addition to larger farms, the rest of the industry is also consolidating. Processing and marketing firms are becoming larger and more closely linked through specified contracts with farms.

Markets--Response to Supply and Demand

<u>Farm Commodity Markets: A Unique Segment of National Economics</u>: The markets for edible farm commodities differ from most other markets due to a unique set of characteristics.

These characteristics include:

(1) Extreme inelasticity in supply and demand for foodstuffs, which can result in rapidly fluctuating prices in the event of an imbalance between supply and demand.

(2) A large number of buyers and sellers of "standardized" products. A bushel of hard wheat looks the same whether grown in Argentina or the Ukraine, and it always sells at a price determined on the world market.

(3) Unsurpassed government attempts to regulate prices through public policy. This process distorts normal market characteristics.

Virtually all nations have public agricultural policies. The psychological and social forces which can be unleashed when food supplies are threatened has been experienced often and are well understood by government leaders around the globe. Unfortunately, national policies often distort market characteristics, and have dramatic and unintended second and third order effects. While recent reforms are bringing about more rational policies in industrialized countries, public policies usually are designed to aid producers and add to supply. In contrast, the government policies in developing countries have often been aimed at holding down food prices to consumers. These conflicting efforts exacerbate the problem of excess supplies in highly developed countries (where it is needed the least) in the face of limited supplies in many poor nations (where it is needed the most).

The price of U.S. farm commodities has steadily declined due to technological and scientific advances which have resulted in increased and more efficient production. Fortunately, the U.S. enjoys a clear comparative advantage in a competitive market. The trend toward freer trade and globalization plays to this comparative advantage, and is therefore in the interest of the U.S.

Biotechnology

Since the beginning of agrarian societies, farmers have used hit-or-miss selection techniques to get the best yields from their most productive plants and animals. In nature, the normal breeding process often crosses hundreds of thousands of genes at a time. Using new biotechnology processes, scientists can manipulate one gene at a time. The results of this genetic engineering are foods that taste better, have richer colors, are more resistant to drought and disease, and are produced more efficiently, with less dependence on chemical fertilizers, pesticides, and herbicides.

The booming world population, expected to double to 10 billion by the year 2030, puts tremendous pressure on the agriculture industry. Biotechnology holds the potential to meet this pressure without destroying the world's ecosystems.

The "Flavr Savr" tomato, genetically engineered to preserve freshness, has been approved by the Food and Drug Administration (FDA) for marketing. A genetically engineered, viral resistant yellow squash is on its way to market. The same potential also applies to other crops such as cantaloupes, watermelon, cucumbers, potatoes, sweet potatoes, lettuce, alfalfa, cotton, and corn. Future yields for these crops are expected to be substantially increased while using less arable land, water, chemical fertilizers, insecticides, and herbicides.

For all the good that agricultural biotechnology promises, concerns have risen about its safety and ethics, including concerns about the level of government involvement and whether government can adequately regulate biotechnology. Food

and Drug Administration (FDA) approval of bovine somatotropin (bST) was delayed ten years and porcine somatotropin (pST) is still awaiting approval, even though there is no evidence that either affects human health in any way. (Both are naturally occurring growth hormones, that are laboratory produced.) Consumer activist groups have increased the fear of "Frankenfoods," and have generated a widespread perception of scientific irresponsibility and inadequate government regulation.

A lack of unity and consistency between the Environmental Protection Agency (EPA), FDA, and USDA regarding regulatory policy propensity toward biotechnology innovators has created doubt and a lack of predictability. This may have a negative impact on the industry and undermine public confidence in the ability of these agencies to oversee the safety and ethical aspects of the food industry.

Human Capital

Agribusiness and its related industries encompass a large and diverse segment of the population, both directly and indirectly, and employ a wide variety of technicians, tradesmen, laborers, and professionals. At the fundamental level of production, the farmer must be well educated and versed in many disciplines. Even the lower echelons of farm labor require skilled expertise often difficult to acquire. For example, the pruning of vines and fruit trees require unique skills in order to maintain plant health and ensure maximum harvest. In California, a peach grower told of a visiting Congressmen who was concerned about the influx of unskilled labor illegally migrating to this country. The farmer challenged the Congressman to climb a ladder, balance a collection sack, and pick only the fruit that was ripe and ready for harvest. After only five minutes, the Congressman admitted he did not have the skills or the stamina to properly perform the job.

Technology-Information and Automation

Historically, agribusiness has applied fully-mature technologies to production processes for harvesting, collection, value-added processing, packaging, and distribution. In more recent years, agricultural industries have achieved significantly higher levels of efficiency through the replacement of labor intensive processes by automation. Widespread mechanization has reduced labor requirements except for those activities requiring high levels of skill, expertise, or sensitive handling--such as pruning fruit trees, and harvesting delicate fruits and vegetables. Savings achieved through automation have continued to drive down the cost of food relative to other consumer products.

Simultaneously, automated equipment used to monitor such activities as hatcheries, fermentation tanks, and grain elevator pipelines has maximized output with safety.

In today's marketplace, the farmer-businessman is highly dependent on information technology to determine market conditions, reduce market risks, process sales and orders, schedule transportation, determine feed and other input requirements, monitor collection of milk, run labor payments, and project rain and frost conditions. He is as likely to have a personal computer in his office as a cow in his pasture.

The USDA, as government's representative is--and should continue to be--the provider of general use information available for all agriculture producers. Information technologies are changing and the private sector is assuming a greater share of the burden for gathering data. However, only the government is capable of providing some of this data on a consistent and reliable basis, particularly information which affects production and marketing decisions at the global level.

While space-age technologies promise opportunities to ensure sustainable agriculture for future generations, their application today is limited by cost, effectiveness, and access. Once available on the open market and economically feasible, there is no doubt that agribusiness will welcome access to such technologies as Global Positioning Systems, Geographic Information Systems, and other prospective advances for precision agriculture.

Performance

No other country in the world outperforms the U.S. in agribusiness. The widespread application of technology, consolidation, and integration of U.S. farming has led to dramatically decreased costs and increased output. The industry's unparalleled effectiveness is best measured by its sustained self-sufficiency and the vast selection of market goods in our stores. We also export over a quarter of our farm products every year. The U.S. remains a leader and trend setter in world markets. We have produced exportable surpluses for decades, and we continue to lead the way in exporting to expanding global markets. Our open markets, participation in trade agreements, and barrier reduction initiatives have been the example for others to follow.

GLOBAL ISSUES AND TRENDS

International Trade

Major Country Markets for U.S. Agricultural Product: From the earliest days of our country, trade has been a key determinate of the cropland dedicated to producing agricultural goods. Export to international markets is vitally important to the U.S. agribusiness community. The United States is projected to export a record $48.5 billion in farm products this year. The farmer of the 1990s is increasingly viewed as a businessman who must succeed on the basis of business performance in the global economy.

The necessity to identify and expand foreign markets for agricultural products should be obvious. Six countries/regional areas account for 63.5 percent of U.S. agribusiness exports and have a market value approaching $29 billion.

Japan: The largest export market for U.S. agricultural products continues to be Japan. During 1993, Japan imported over $9.1 billion worth of agricultural products from the U.S., accounting for over 20 percent of total U.S. agribusiness exports. Japan is expected to remain a lucrative export market until the end of the century, but should not be taken for granted. Changing consumer attitudes, farm output, consumer purchasing power, and dietary preferences also enter the marketing equation. Simultaneously, other producers are now competing with the U.S. to supply the Japanese market.

Other Asian Countries: Other Asian countries have recently jumped ahead of Japan as the leading importer of selected U.S. commodities. In 1993, Hong Kong replaced Japan as the top market for poultry, and South Korea became the top ranking market for U.S. cotton. A major contributor to this increase was a provision in the General Agreement on Tariffs and Trade (GATT) that removed or reduced quotas for some processed farm products. The future looks bright for increased grain exports to China as their population grows and shifts to urban areas. Taiwan and other smaller Asian nations, coupled with the above mentioned countries, accounted for $17.9 billion, or over 40 percent, of our agricultural exports in fiscal year 1994.

European Union (EU): Following closely behind Asian nations in the value of U.S. agribusiness goods imported are the 15 countries comprising the European Union. With their substantial per capita income and strong desire for value-added American products, they will continue to provide substantial export opportunities. Note: Eastern European countries continue to work through political, economic, and social problems, and could prove to be a major player as market-oriented economies and more stable political systems emerge. A big question in the global market for agricultural products is the level of future development in the Former Soviet Union (FSU).

Canada and Mexico: North American neighbors Canada and Mexico will continue to be the lead markets for many U.S. agricultural products in 1995. In 1994, 12 percent or $5.2 billion of U.S. agricultural exports went to Canada. Agricultural tariffs affecting this market are scheduled to be reduced to zero by 1998 under the U.S./Canada Free Trade Agreement. Mexico and other Latin American countries receive about 17 percent of our agricultural exports. They also provide the U.S. with its greatest amount of agricultural imports. Trade reforms and the successful completion of the North American Free Trade Agreement (NAFTA) are encouraging signs.

Future: The decade of the 1990s will produce dramatic changes for U.S. agribusinesses as the industry integrates more fully into an extremely competitive world market. The American farmer and the rest of the industry must rise to meet the challenge of increased demand for products by a growing and prospering world population. Evolving global markets provide unlimited opportunities for the United States agribusiness industry to grow both at home and abroad.

Comparison of U.S. and EU Agribusiness

The United States has been one of the world's largest agricultural producers and exporters since the 19th century. Government policies have aided American agriculture in becoming one of the most effective and productive sectors of the U.S. economy. However, in the 1980s the European Union (EU) began to export large quantities of agricultural products causing the U.S. to question its farm policies and how these policies affected trade for the world's largest exporter of agriculture products, the U.S.

The European Union : The EU, previously known as the European Community, was formed by the Treaty of Rome on March 25, 1957. The EU has a population of approximately 350 million and a gross domestic product of over $6 trillion. The EU and the U.S. are each other's largest trading partners in total trade. The EU is the world's second largest exporter of agricultural products behind the U.S. The average farm size in the EU (before Austria, Sweden and Finland joined in 1995) was 14 hectares (35 acres). In 1989, the number of farms in the EU in 1989 was slightly over 8 million and the percent of the EU population involved in farming in 1992 was 5.2 percent.

The United States: The U.S. is a country with over 260 million people and a gross domestic product of over $6 trillion. The number of farms in the U.S. is decreasing and farm ownership is becoming more concentrated. For example, during the depression there were nearly 7 million farms in the U.S. and farm families made up nearly a third of the nation's population. In 1995, only two percent of the nation's population are considered working farmers and there are approximately 1.9 million farms. The Bureau of Census defines a farm as any place that has or would have

had $1000 in gross sales of products. However, the U.S. considers only 800,000 farms as active commercial farms, and of those 300,000 produce 85 percent of all farm products. U.S. farm policy has not only helped make the nation self-sufficient in agriculture, it has also helped keep the American citizen's share of disposable income spent on food consistently lower than other industrialized parts of the world. For example, in 1995 the U.S. consumer's food expenditures as a share of personal disposable income, after taxes, was less than 11 percent. This compared favorably with the EU's 21 percent.

EU Farm Policy: The EU Common Agriculture Policy (CAP) includes price supports (at about twice the world level), direct payments, import levies, export subsidies, public storage, processing and consumption subsidies, and structural measures.

U.S. Farm Policy: The farm programs put in place in the 1980s in the U.S. left American farmers unable to respond to dramatically difficult and rapidly changing market conditions. The high U.S. loan rates acted as an umbrella for several foreign markets, encouraging overseas production. The U.S. price umbrella was among the factors that helped transform some foreign markets from U.S. customers to U.S. competitors. The Farm Bills of 1985 and 1990 have done much to correct the errors of the early 1980s. The key components of current U.S. farm policy are target prices, lower price support loans (close to world market levels), deficiency payments, base and flex acres, and the Export Enhancement Program.

Comparison of U.S. and EU Agribusiness Policies: Farm programs in the EU and the U.S. are similar in that they have been very effective in helping achieve self-sufficiency and developing the largest export systems in the world. How these two systems differ is primarily in the way farmers are compensated and the level of efficiency and productivity. Agriculture spending under the CAP amounted to nearly $45 billion in 1995, compared with about $10 billion for commodity support in the U.S. (The U.S. has other expenditures that effect agriculture, e.g., food stamps and surplus disposal programs).

The EU must make dramatic changes to comply with the provisions of the WTO. Even so, the EU will continue to be a major player in the world's agricultural market; however, the U.S. is in a much more competitive position to benefit from the WTO provisions. The new WTO rules are projected to increase U.S. agricultural exports by $1.6 - $4.7 billion in 2000 and by $4.7 - $8.7 billion by 2005. Increased U.S. exports will also mean more export-related benefits, particularly exports of high value-added products. Increased exports will raise farm prices, increase farm income, and lower government outlays on price and income support programs.

In summary, the EU and the U.S. farm policies are very similar. Total expenditures are equivalent; however, the EU provides most of their subsidies via increased support prices which raise costs and distort markets. These types of payments will have to be reduced or eliminated under the provisions of the WTO.

Global Free Trade

The trend toward global free trade continues with WTO and regional "NAFTA-type" trade agreements. The trend toward global free trade is especially favorable to U.S. agribusiness which enjoys a comparative advantage in many areas. However, rapid movements to unrestrained global free trade in agricultural products could destabilize some emerging nations. Many third world countries have the majority of their work force dedicated to the inefficient production of crops and livestock. They cannot effectively compete in global markets. The rapid elimination of support for these nations' agribusiness industries would result in widespread, and politically unacceptable, unemployment. For this reason, GATT affords emerging nations an additional five-year grace period for compliance with the requirements to establish a level playing field for their agribusiness industries. In the long run, baseline standards of economic and political stability will be the price of admission for any country wanting to compete as an agribusiness free trade partner.

Distribution

The U.S. has not only the ability to distribute food products on a daily basis, but also the ability to provide rapid and efficient emergency distribution of food. The strategic capability to transport food to any corner of the globe is mirrored in the U.S. "civilian" transportation infrastructure. Its air, rail, sea, and overland capabilities are unequalled. Using state-of-the-art communications and distribution systems, along with intransit visibility systems, allows the U.S. to be truly global in its reach. The U.S. ability to master these third wave systems will enable it. to participate in any arena, any time. However, these projects all require significant investment--and the federal components of some programs are under scrutiny in the upcoming budget.

Migration

Agriculture and associated agribusinesses have historically been, and continue to be, key industries influencing the migration of laborers. There are two distinct factors that come in to play: one as an economic/social "push," the other as a "pull."

Push: Rural workers in developing countries facing reduced opportunities in agriculture are "pushed" away from homelands that no longer offer sustainability (either from lack of economic opportunity, pollution, war, or expanding urban areas). These individuals migrate to areas with greater economic opportunity or new agricultural homelands.

Pull: Other groups are "pulled" into new areas by the promise of more profitable work in other industries. These people are leaving farms for greater economic and quality-of-life opportunities in other industries often located in urban areas. The impact on the "gaining" society is an additional supply of low-cost labor

coupled with pressures on support services and infrastructures. The impact on the "losing" nation is loss of generally useful youth who have left declining job markets for higher earnings and income opportunities.

Environment

Global: Global concern over environmental degradation has sparked an interest in "sustainable development" as a concept for emerging nations to pursue in an attempt to minimize pollution and arrest soil and water losses. However, difficulties in acquiring funds from the industrialized world have limited progress in this important area. Increased awareness in the U.S. and other developing countries will be needed to mobilize the necessary financial support to further this work in poorer areas of the world.

It is unclear if global leaders are fully aware of the dangers imposed by environmental degradation. While U.S. leaders acknowledge the requirements to protect the environment, the U.S. role in global politics has placed little emphasis on environmental protection.

With the expansion of agribusinesses in developing nations, "desertification" can occur. The decrease in rain forests, the expansion of cities, the sprawl of suburbs, and general encroachment by "civilization" have resulted in soil erosion, decline in rainfall, soil contamination, loss of plant and animal habitats, and destruction of healthy natural environments for many species.

In some regions, conflicts and wars have resulted from the loss of agricultural output and the rationing that followed environmental destruction and/or degradation. The United States' security is subject not only to the quality of its own environment, but also that of other nations and regions.

Domestic: Agribusiness, and agriculture in particular, are challenged to meet the delicate balance between good business practices and ecological balance. Agribusiness is dependent on a healthy soil and water base as the foundation for its elementary inputs (e.g. organic input to plants and animals).

Agribusinesses are challenged to decrease, if not eliminate, such damaging externalities as fertilizer run-off and process-plant effluent. To meet these challenges, forward thinking business leaders are seeking uses for all remediated products. Such items as pet foods, farm feed, and natural fertilizers are examples of products created through these efforts. Use of all animal parts through the identification of new product markets has also eliminated slaughter waste (e.g. offals to Europe and chicken feet to Asia and other markets).

A major challenge to U.S. agriculture lies in water availability and use in

California, the nation's largest agriculture producer. Today, users and legislators continue to debate existing water resource allocation rather than address new water production methods. Scientists focus on plant hybrids to develop species requiring less, or previously unusable, water for growth and harvest. As population growth, recreation, and other requirements demand water, the issue of water resourcing will become more critical to maintaining the ecological balances required to feed the nation and the globe.

The U.S. needs to continue to emphasize domestic environmental health concerns and pursue global emphasis regarding preservation of sensitive environments while providing aid and assistance to economic and social/political growth partners.

World Hunger

Asia, Africa, and Latin America produced more than half of the grain harvested in the world. This included: 95 percent of the rice, 42 percent of the wheat, and 34 percent of grains such as maize, sorghum, and millet, called "coarse grains" in the language of the international grain trade. However, at least half a billion people in these regions, about 10 percent of the Earth's population, lacked enough food to eat while another half billion lived hand-to-mouth, at constant risk of hunger. Two key problems are:

Poverty: One-third of the world's population lives below the poverty level. The population living below the poverty level is 86 percent in Bangladesh, 61 percent in Nepal, 50 percent in India, and 41 percent in the Philippines. The dire effects of poverty are localized hunger, malnourishment, and starvation. Areas of the most severe poverty are also hindered by nonexistent roads, inadequate communications, and people living outside the economic mainstream. These myriad problems collectively contribute to the calamity of hunger, because even world food relief organizations cannot distribute the necessities of life to these people.

Role of Women: The role of women in both sustainable economic development and long term nutritional security is poorly understood. The labor of women produces almost half of the world's total food. In Africa, three-fourths of the agricultural labor is performed by women who produce almost 90 percent of the food in some rural areas. Africa's declining food security posture is not being viewed in light of the adverse impact on women of modernization schemes that: assign land title to individual "heads of household" and assume this means the husband; provide credit only to landowners, who are by definition only male; introduce mechanization to which only men have access; and stress production of export crops that compete with women's domestic crops.

Research by the United Nations estimates that women perform almost two-

thirds of all the hours worked in the world, receive one-tenth of the income, and own less that one percent of the world's property. Any effective foreign or domestic policy must recognize the complexity of the world hunger problem.

GLOBAL POLICIES

U.S. Government Role In Agribusiness

The USDA is the federal agency entrusted with the responsibility for ensuring the long term health of the agribusiness industry is maintained at an acceptable level. However, the absence of a clearly articulated, coherent, and complete USDA strategy or vision has led to deployment of an unfocused federal agribusiness oversight effort. This current effort relies heavily on historical precedence, a "common understanding" of national interests, inertia, and political pressure for direction.

The federal government's complex web of antiquated agricultural price support policies, direct payments, regulations, legislation, R&D decisions, and barriers to competition from foreign companies has had trouble keeping pace with technology and market changes. Moreover, it does not appear to follow any consistent pattern or form. The federal government is actively engaged in price protection in the tobacco, peanut, dairy, and sugar sectors, among others. Possibly more vital agricultural sectors receive no federal assistance, support, or protection whatsoever.

Given American agribusiness' stature in the global community, one might conclude that the federal government's past practices suited the demands of the industry. However, the fact that America's agribusiness industry is the envy of the world is not a result of the wisdom of the U.S. government's disjointed involvement in oversight and the default resource strategy that guides it. Specifically, the existing programs and policies have not kept pace with either national or international market changes.

FEDERAL GOVERNMENT'S ROLE IN AGRIBUSINESS

Today's robust U.S. agribusiness sector owes its strength, in large part, to the active role the federal government played in the early years of national development. Farm and range policies that created security and continuity provided the foundation for expansion, modernization, and product safety. Today, however, these same policies burden the industry with unnecessary price supports, direct payments, and tariffs which distort the market and often penalize consumers and taxpayers.

Direct payments to farmers include, but are not limited to, paying farmers <u>not</u> to grow crops. Price supports penalize the consumer by creating artificially high prices in the marketplace, and may also cost the taxpayer a second time if the government must step in to purchase goods unsold at market set prices. These programs are

redistributive income from the consumers and taxpayers to the farmer. This is accomplished by acquiring tax revenues or by overcharging consumers for agricultural products.

A third form of market distortion takes place when tariffs and quotas are imposed on imported goods. Quotas reduce supply and drive up prices. Tariffs raise the cost of the imported good in order to protect domestic output. Such practices deter competition and support continued domestic production of goods.

From an international perspective, support to U.S. domestic producers has the potential to damage markets in other, perhaps less efficient, food growing regions. Many developing nations' agricultural industries cannot compete with U.S. subsidized products. Furthermore, direct payments to U.S. farmers who produce export goods amount to transfer payments from U.S. taxpayers to foreign consumers at the expense of foreign farmers. American agribusiness can compete globally without the market distortions created by government assistance.

Research and Development

Throughout this century, growth and sustainment of agribusiness has been underpinned in a large part by individuals and institutions conducting R&D. This $4 billion plus effort is divided among federal and "market driven" R&D as follows:

(1) 26 percent of agribusiness R&D expenditures come directly from federal bodies responsible for the nation's strategic direction -- USDA and Congress.

(2) Conversely, "market driven" R&D--that is R&D resource allocations made by profit-driven individuals, agencies, or corporations--accounts for some 53 percent of all activity.

(3) 21 percent of agribusiness R&D expenditures come from "other" sources.

While total R&D funding over the past decade has grown 67 percent, there has been even greater growth in the relative share of R&D supported by "market" sources. Private enterprise and state contributions are up approximately 100 percent.

Competitiveness of American agribusiness is dependent upon a world class R&D program. Evidence clearly supports a policy of reduced <u>direct</u> federal involvement in agribusiness R&D and continued state and private initiatives. USDA should ensure that the world standard for agribusiness R&D systems is resident in America, but <u>the federal government should not be in the business of conducting R&D</u> except in those unique instances where the states and private industry cannot be motivated to conduct the R&D under their auspices.

RECOMMENDATIONS FOR THE FEDERAL GOVERNMENT

Reduce Federal Government Market Manipulation. In the past the Federal Government's direct involvement in agriculture was warranted. Conditions have changed, and that involvement is no longer justified. We envision a significantly reduced role for the U.S. Government in agribusiness. Specific recommendations are:

Eliminate, in a phased manner (sunset), subsidies and tariffs to U.S. farmers.
The robust agribusiness sector owes its strength, in large part, to the active role of the federal government in the early years of development. Today, however, these same policies burden the industry through unnecessary price supports, direct payments, and tariffs which distort the market and penalize consumers.

Limit the role of the Federal Government to only those areas that cannot be managed and directed efficiently and effectively by market forces, the business community, private and nongovernmental organizations, and state and local governments.
When the Federal Government becomes directly involved in activities which can be directed equally well by other organizations or free market forces, the result is a less efficient and effective effort.

Take a Leadership Role in Technology. United States scientific and business communities are keenly attuned to the needs and desires of consumers and are therefore capable of leading and directing research and development efforts in agribusiness-related technology. In spite of their ability to effectively and efficiently direct this aspect of technology, we envision a leadership role for the Federal Government related to the safety and ethics of technology-related products and services. Specific recommendations are:

Encourage commercial research and development in biotechnology that hold the potential to feed an exploding population, and provide better, more productive, more resilient, and cheaper products.

Assume the role of "honest broker" for matters related to safety and ethical matters in technology-related products and service.
While biotechnology holds the potential for enormous good, concerns have arisen about industry's and government's roles in safety and ethics. These concerns have generated a widespread perception about scientific irresponsibility and inadequate government regulations to protect the public.

Nurture commercial development and availability of information technology that provides farmers with the management tools needed to succeed in the modern world.

Today's farmer must be cognizant of factors affecting production and marketing of commodities, futures and other instruments to manage financial risk, government regulations, environmental and ecological factors, and application of new technologies.

<u>Create incentives for the commercial development of production technology that supports the global market position of the U.S. farmer.</u>

Technology has historically been a force that leads to increased productivity and yield. These trends will continue and should be accelerated by the Federal Government.

<u>Build consumer confidence in biotechnology related products.</u>

The Government must be open and honest in providing information to build and maintain public confidence. The Government must assume the role of "honest broker" and act as an impartial provider of information regarding the safety of technology-based agricultural products.

<u>Take a Leadership Role in Solving World Hunger</u>. Hunger, malnourishment, and starvation are persistent and challenging problems for the world. The U.S. has a vital national interest in the incidence of world hunger and its related effects: human suffering, mass migration, civil unrest, and decreased world productivity. The U.S. needs to take a leadership role. Specifically:

<u>Lead the world fight against hunger</u> by developing a multi-faceted program to reduce poverty around the world, develop assistance programs that recognize the role of women in agriculture, direct development efforts at farmers in underdeveloped areas, and carefully apply technological solutions.

Feeding the world's exploding population will continue to be a challenge. Hunger is a complex, multi-dimensional problem with no single solution.

<u>Recognize the Linkages Between Agribusiness and National Security</u> U.S. agriculture, and the related agribusiness industries, are the foundation upon which much of the nation's success is built. Food has always been available within the U.S. Americans spend a relatively small portion of their disposable income on food, and as farm efficiency has risen, individuals and the economy at large have been able to turn their efforts to other endeavors. We need to recognize the critical role that agribusiness plays as an element of U.S. national strength, and promote laws and regulations that foster and nurture this strategic sector. Specific recommendations include:

<u>Recognize that America's agribusiness industry has been, and will continue to be, an essential element of this nation's economic, political, and military strength.</u>

U.S. agribusiness is a critical, albeit "behind the scenes" element of national security. Its success, efficiency, and effectiveness contribute a large positive

balance of trade and allow the U.S. consumer to spend less of his disposable income on food and has allowed people and capital to leave the farm for other, vital endeavors.

Develop policies to strengthen U.S. agribusiness.
The Federal Government must promote policies and programs that make this segment of the industrial sector more competitive.

Take a Leadership Role in U.S. Agribusiness. We envision a reduced role for the U.S. Government in agribusiness. However, we also believe there are some critical areas where the Federal Government needs not only to be involved, but also needs to take a leadership role. Specific recommendations include:

Recognize the unique role and requirements labor plays in U.S. agribusiness. Develop policies and programs that ensure an available and affordable work force consistent with the needs of U.S. agribusiness.
U.S. agribusiness is a significant industry, representing 17 percent of the GDP and accounting for a projected record $48.5 billion worth of goods in 1995.

Assist the farmer by ensuring that he is "plugged-in" to global information.
Today's modern farmer must not only be aware of "on the ground" crops and livestock, but must also be up-to-date on financial and commodity trends, market forces, and weather predictions. The farmer must be global in his perspective in order to remain globally competitive.

Actively promote U.S. agribusiness exports. Recognize the key nature that agribusiness has in the U.S. balance of trade.
Japan, Asia, the European Union, Canada, and Mexico will account for 63.5 percent of exports with a market value approaching $29 billion. The U.S. should foster opportunities to increase trade with China and the FSU.

Recognize the evolving nature of the EU as a world trader in agribusiness. Take a strong position with regard to trade issues where necessary to ensure fair treatment of U.S. farmers.
The United States has been one of the world's largest agricultural producers and exporters since the 19th century. However, in the 1980s the European Union, as a single entity, began to export large quantities of agricultural products with export subsidies. Currently, the EU is the world's second largest exporter of agricultural products behind the U.S.

Ensure that the agricultural provisions of GATT are realized.
The farm programs in the EU and the U.S. are similar. However, the EU must make significant changes to comply with the provisions of GATT. The EU will continue to be a major player in the world's agricultural markets; however, the

U.S. is in a much more competitive position to benefit from GATT.

Actively engage world leaders in promoting the continued liberalization of global free trade.

The trend towards global free trade is especially favorable to U.S. agribusiness which enjoys a comparative advantage in many areas.

Take a leadership role in protecting the interests of not only the U.S. farmer, but also the public at large, by establishing policies that recognize the fragile and critical nature of the environment.

Concerns about the impact of any industry, including agribusiness, on the environment will continue to be central to policy discussions. Careful consideration of environmental consequences are essential to the health and survival of the planet.

Promote the collection and dissemination of general use information that maintains the position of the U.S. farmer as the most productive, efficient, and competitive farmer in the world.

The USDA as government's representative to the agribusiness industry is, and should continue to be, a provider of general use information available to the entire agricultural community. While information technologies are changing, only the government is capable of providing some of this data on a consistent and reliable basis, particularly that information that effects production and markets at the global level.

Cultivate the continued market driven consolidation and integration of U.S. farming and marketing by promoting appropriate policies.

Consolidation and integration has led to decreasing costs and increasing output. Effectiveness has been measured by our self-sufficiency and vast selection of market goods in stores.

CONCLUSION

U.S. agribusiness is the best in the world and its future is bright. As the world leader, the U.S. sets the standard.

INDUSTRY STUDY

#4

AIRCRAFT

TABLE OF CONTENTS

PARTICIPANTS

Students

LTC Ronald R. Blickley, USAF

LTC Louis A. Bonham, USA

CAPT Gregory A. Brown, (SEL), SC, USN

LTC Steven W. Brown, USAF

COL Bradley W. Butler, (SEL), USAF

LTC Michael P. Chapin, USAF

LTC David R. Darrah, USMC

COL Mustafa Firat,, Turkish Air Force

COL Patrick K. Halton, (SEL) , USMC

S. Diane Lamb, OSD

CAPT Dana F. Miller, USN

Gross Scruggs, D/N

Kathryn J. Sowers, D/AF

COL Robert L. St. Thomas, USAF

Nicholas J. Verna, DLA

LTC Robert M. Williams, USA

Faculty

COL Michael P. Smith, USAF

COL Christopher B. Stoops, USMC

CAPT Fred L. Meyer, SC, USN(RET)

Dr. Rolf H. Clark, CDR, USN(RET)

PLACES VISITED

Domestic

Aerospace Industries Association (AIA)	Washington, DC
Pratt & Whitney Aircraft	East Hartford, CT
Sikorsky Aircraft	Stratford, CT
Shultz Steel	South Gate, CA
Northrop Aircraft	Palmdale, CA
Lockheed Advanced Development Company	Palmdale, CA
Douglas Aircraft Company	Long Beach, CA
Boeing Aircraft	Seattle, WA
McDonnell Douglas	St. Louis, MO

International

British Aerospace	Lancashire, UK
EH Industries	London, UK
United Kingdom Ministry of Defence	London, UK
Rolls Royce Aerospace Group	Bristol, UK
Dassault	Paris, France
SNECMA	Villaroche, France
Aerospatiale	Toulouse, France
Airbus Industrie	Toulouse, France

GUEST SPEAKS

Dr. Bert Cooper	Congressional Research Service
Mr. Robert Griswold	General Electric
Mr. Jack Modelewski	Paine Webber
Mr. Adrian LeRoy	McDonnell Douglas
Mr. James A. Wrightson	McDonnell Douglas
Mr. Jerry Marsh	Boeing Aircraft Company
Mr. Tom Shields	Massachusetts Institute of Technology
Mr. Vincent L. Rausch	NASA
Ms. Sally H. Bath	U.S. Department of Commerce
Mr. David Morgan North	Aviation Week & Space Technology
Mr. Robert R. Ropelewski	Interavia

INTRODUCTION

The aircraft industry is comprised of firms which produce aircraft, engines, and related parts (Standard Industrial Classification (SIC) 372). Major product sectors include commercial and military fixed wing aircraft, helicopters, and aircraft engines. It is an industry of strategic importance to the United States providing the U.S. economy with total exports of $36.4 billion and a trade surplus of nearly $24 billion in 1994.

The aircraft industry experienced rapid sales growth, averaging 3.7 percent annually, from 1980 through 1990. However, commercial aircraft markets in industrialized countries are largely developed and most future business is for replacement aircraft. Newly industrializing countries provide the largest growth markets in percentage terms, but the small size of their economies limits their near-term impact on worldwide aircraft sales. Commercial aircraft are becoming commodities with price and cost of operation being the primary means of differentiation between competing products. Military aircraft sales have also peaked as countries worldwide reduce their defense budgets in the wake of the Cold War. For example, the U.S. has reduced its overall defense procurement budget by 71 percent, in constant dollars, since its peak in 1985.

Both commercial aircraft and military aircraft sales, which operated counter-cyclically before the end of the Cold War, have simultaneously entered a period of depressed sales. The 1994 sales of civil aircraft, engines, and parts, at $26 billion, was 37 percent below its 1992 sales peak in constant dollars. The 1994 sales of military aircraft, engines, and parts, at $32 billion, was 40 percent below its 1987 sales peak in constant dollars.

Although the industry is slowly recovering from the recent recession and military downturn, long-term prospects for commercial aviation sales are good. There is a potential for $1 trillion in sales through 2013. Factors which could potentially slow the upturn in commercial sales are the existing oversupply of commercial aircraft and unprofitable airlines which are burdened with high yield debt. We also believe that future military procurement spending will stabilize and spending for military procurement will eventually need to increase if present force levels are to be sustained. However, the future demand for military aircraft will be dampened by political pressure to attain a balanced federal budget and a perception of reduced threat to national interests.

AIRCRAFT INDUSTRY OVERVIEW

We have analyzed four sectors of the U.S. aircraft industry:

- Large Commercial Transport Aircraft (over 100 seats)

- Military Fixed Wing Aircraft
- Rotary Wing Aircraft (military and civil)
- Aircraft Engines

The commercial transport sector is composed of revenue passenger carrying aircraft of over 100 seats and their cargo aircraft derivatives. In 1994, commercial transports represented 32 percent of the $58 billion total in U.S. aircraft sales. The military aircraft sectors consist of tactical and strategic aircraft without commercial applications. Despite defense downsizing, in 1994, military aircraft still represented 55 percent of U.S. industry's aircraft sales. The aircraft engine segment includes a wide variety of power plants from small piston engines to large turbofans. As an indicator of relative sector size, the sale of aircraft engines and parts in 1993 accounted for 21 percent of total U.S. aircraft sales. This report is concerned with only the large jet engine manufacturers. General aviation aircraft represent another sector which consists of small business jet, commuter turboprop, and private aircraft. In 1994, sales in this sector rose to the highest level since 1981, but still accounted for only 4 percent of U.S. aircraft sales.

Although thousands of companies are involved in the aircraft industry, most participate as subcontractors and component vendors. This report covers only the few firms which serve as prime item developers within each market segment. At this level, all market sectors are highly concentrated. Worldwide, three manufacturers (Boeing, Airbus Industrie, and McDonnell Douglas) ship the vast majority of large commercial transports, and the large jet engine sector is dominated by four firms worldwide. For the U.S. military market, only two U.S. manufacturers are likely to produce tactical fixed wing aircraft by the year 2000. Similarly, in the rotary wing sector, where four U.S. firms currently act as prime contractors, the future business base is likely to force industry consolidation.

There are significant barriers to enter the aircraft manufacturing market. Workers are highly skilled, and the industry uses sophisticated design, tooling, and manufacturing technology. The cost of developing a new passenger aircraft can exceed $6 billion, and developing a new engine can exceed $1.5 billion. Future aircraft developments such as the very large civil transport and the high speed civil transport could cost $8 billion and between $12-14 billion respectively.

A high level of research and development is a hallmark of the aircraft industry. The U.S. aerospace industry accounts for more than 13 percent of the nation's industrial research and development expenditures. In 1993, 12 percent of the nation's research scientists and engineers were employed in aerospace. Governments are closely involved in the conduct of aeronautics research with total estimated U.S. federal expenditures of $11.4 billion for aeronautics research in 1993. This U.S. Government expenditure was divided between NASA with $1.2 billion, the Department of Defense with $7.6 billion, and the Department of Transportation with $2.5 billion.

U.S. Government aeronautics research has recently declined, and NASA's 1995 budget for aeronautics research is approximately $850 million.

The aircraft industry also has a significant impact upon the U.S. economy. Output of the U.S. aircraft industry currently represents approximately one percent of U.S. gross domestic product. This output level has recently declined with total employment in the U.S. aircraft industry falling 31 percent below the peak employment achieved in 1989 to 484,000 in 1994.

Although its market share has been declining, the U.S. is still the world leader in aircraft sales. In 1970, the U.S. led the global (non-Soviet) aerospace market with a share of almost 80 percent. By 1993, the U.S. still led the world, but U.S. shipments had shrunk to less than 60 percent of the world market. The aerospace industry is still the nation's leading net exporter of manufactured goods, exporting products worth $36.4 billion in 1994.

Despite its high glamour, aircraft manufacturing has not been particularly profitable. Intense competition and large capital requirements constrain industry profits. Between 1979 and 1993, aerospace industry profitability measured by return on sales (ROS) averaged 3.3 percent. This was significantly below the average ROS for all manufacturers of 4.1 percent. In 1994, aerospace industry ROS was 4.7 percent. High aerospace capitalization requirements are indicated by profitability as measured by return on assets (ROA), which averaged 3.7 percent, also significantly below that for all manufacturers of 5 percent. In 1994, aerospace industry ROA was 4.3 percent. In contrast with ROS and ROA, aerospace industry profitability as measured by return on equity (ROE) is roughly equivalent to that for all manufacturing. Aerospace industry ROE averaged 11.7 percent while the average for all manufacturers was 11.1 percent. To achieve this performance in ROE, aircraft industry firms must operate at higher leverage ratios than manufacturing as a whole. In 1994, profit margins raised the industry's ROE to 15.2 percent, the highest return since 1981, and this closely matched the average ROE of 15 percent for all manufacturers in 1994.

During the recent sales downturn, aerospace industry capital investment declined from its peak in 1992. Since that time, the industry's net working capital has decreased by 7 percent to $14.2 billion. In 1994, expenditures for new plant and equipment were $2.95 billion, down 33 percent in constant dollars since 1990.

COMMERCIAL TRANSPORT SECTOR

Structure of the Commercial Aircraft Transport Sector

The commercial transport sector includes all passenger aircraft with 100 or more seats (SIC code 37215 - civilian aircraft). This market is an oligopoly dominated by three major manufacturers, Boeing and McDonnell Douglas in the United States and Airbus Industrie in Europe. The market for commercial aircraft grew rapidly through 1990, but due to market saturation and global recession, it has recently entered a period of reduced sales. Continued rationalization within this industrial sector is to be expected if manufacturers intend to remain profitable and stay in business.

Barriers to entry into this market are substantial. This industry is highly capital and labor intensive with formidable technical and financial requirements. Developing a new, large commercial jet currently costs about $6 billion. For example, Boeing spent nearly $1.5 billion to double the size of its Everett, Washington, factory to accommodate production of the 777 aircraft.

This sector is characterized by increasing international competition. Until the 1980s, U.S. airframe manufacturers had a virtual monopoly on world civil aircraft production. But by the end of 1993, U.S. manufacturers maintained 65 percent of the current world backlog of firm orders for large aircraft, and Europe's Airbus Industrie had established firm control over the number two position with 34 percent. International competition and cooperation are also evident at the subsystem and component level. Thousands of subcontractors fabricate between 60 and 70 percent of the value of American airframes. To share risks and satisfy demands of national governments, all airframes and most engines are now built by multinational partnerships. Gradually, U.S. manufacturers have increased the foreign content of their aircraft. In 1959, the percentage of foreign products installed on the Boeing 727 was approximately two percent. Launched in 1978, the Boeing 767 has a foreign product content approaching 15 percent. Recently with the 777 aircraft, almost 60 international suppliers fabricated parts, and Japanese firms provided about 20 percent of the fuselage structure. For McDonnell Douglas' products, foreign content ranges from 15 to 20 percent of the aircraft value on the MD-11 and MD80/90. Airbus Industrie claims that 40 percent of its aircraft value is U.S. content.

The commercial transport market can be divided into five categories based upon aircraft range and seating. These categories are: short range with approximately 100 seats, medium range with 150 seats, medium range with greater than 200 seats, long range with less than 250 seats, and long range with greater than 250 seats. Available aircraft models by the major manufacturers are summarized below in Table

1.

TABLE 1 Summary of Commercial Transport Aircraft Models and Market Segments of Major Manufacturers Model / Seating Capacity / Range (Nautical Miles)			
Range Seating	Boeing	Airbus	McDonnell Douglas
Medium 150	B-737 109-142 2500 NM	A-319 124 2700 NM	MD-80 144 2500 NM
	B-757 180 - 230 4500 NM	A-320 150-164 3000 NM	
		A-321 186-200 2350 NM	
Medium > 200	B-767 206-242 3800 NM	A-300 228-299 4250 NM	
		A-310 187-243 4850 NM	
		A-330 300-350 4600 NM	
Long < 250	B-767 206 - 325 5000 NM		
Long > 250	B-777 305 - 440 5000 NM	A-340 263-295 7700 NM	MD-11 293-335 6940 NM
	B-747 420-566 7200 NM		

Conduct of the Commercial Aircraft Transport Sector

Since 1992, industry management has dramatically reduced production and cut facilities. The labor force has therefore experienced dramatic reductions during that time. In 1993, the number of U.S. production workers engaged in the manufacture of

aircraft, engines, and parts was 252,000, down 27 percent from the peak in 1990. At McDonnell Douglas, employment in the commercial aircraft segment decreased 65 percent, from 35,418 at the end of 1991 to 12,540 at the end of 1993.

Aggressive management has reduced product manufacturing time and cost. Boeing trimmed cycle time--from start to finish--on its B-737 from 18 months to less than 12 and has set a goal of 6 months. At McDonnell Douglas, the average time to assemble an MD-11 decreased to about 120,000 hours in 1993 compared to 400,000, for the first production aircraft, in 1991. The number of months needed to produce the MD-11 was reduced from twelve to five. All these mean less demand for labor.

Governments actively influence this market segment. As a customer, the U.S. government provides indirect assistance to industry. They purchase defense products and fund research and development. McDonnell Douglas sells 60 percent of its products, by value, and Boeing sells 20 percent to the U.S. government. In 1993, McDonnell Douglas Corporation topped the list of DoD contractors in terms of contract dollar value with $7.5 billion. Boeing had $1.7 billion. In contrast to the U.S. government's indirect support, European government support is more direct. A study done for the U.S. Department of Commerce found that four European governments provided nearly $26 billion, when the cost of capital is included, to Airbus Industrie over a 22-year period.

Governments attempt to maintain an appearance of a level playing field for international trade. The U.S. government negotiated two agreements which presently impact trade in commercial aircraft. The first of these agreements was a 1985 Organization for Economic Cooperation and Development (OECD) large aircraft sector understanding. This understanding regulated the loans that governments may offer to promote large aircraft sales. The second agreement, signed in July 1992, was a bilateral agreement between the United States and the European Union on subsidies for the aircraft industry. This agreement prohibits all production supports and sets the limit at 33 percent on the level of permissible government funding for new aircraft programs.

U.S. manufacturers are involved with several ongoing research projects. Boeing's principle developmental projects include the 777 base model, the extended-range version of the 777, initial structural design activities on the 737-700, and the freighter version of the 767. Douglas hopes to launch the MD-95, a 100 seat version of its MD-90. As the industry has matured, major development projects have become increasingly expensive with greater economic risks. For several years, manufacturers have examined the feasibility of developing a 600-800 passenger aircraft. It is believed the project could cost as much as $15 billion, including the cost of capital, while there is a risk the market for this aircraft may profitably support only one manufacturer.

Performance of the Commercial Aircraft Transport Sector

The commercial transport sector is currently in an era of depressed sales. In 1992, sales of transport aircraft peaked at $28.8 billion. Across the U.S. aircraft industry, commercial transport shipments in 1993 fell 16 percent in real terms to $24.1 billion and another 24 percent to $18.5 billion in 1994. According to the Aerospace Industries Association, sales are expected to fall another three percent in 1995.

Sales are expected to be flat through 1997. However, longer term sales prospects are somewhat brighter for three reasons: older planes need to be replaced; carriers will replace aircraft to comply with new noise regulations; and world air traffic continues to grow. Industry estimates for transport aircraft sales vary between 11,000 to 14,000 planes at a value near $1 trillion over the period 1994 through 2013.

The commercial aircraft industry is characterized by cut-throat price competition. In 1987, the MIT Commission on Industrial Productivity concluded that economic failure is the norm in the civil aircraft business, and estimated that jet transports lost their manufacturers some $40 billion on revenues of $180 billion through 1984. At that time, even Boeing failed to make a profit.

In the future, U.S. firms can continue to expect aggressive competition from foreign commercial manufacturers. From 1978 to 1989, Europe's aerospace industry grew twice as fast as the U.S. industry. By 1990, Europe's industry was nearly half the size of the U.S. industry. In 1994, the import share of U.S. trade in transport aircraft rose to 11.5 percent, the highest ever, while the Airbus Industrie consortium announced its intent to increase its market share to half of the commercial transport market.

The future commercial aircraft market is likely to remain highly cyclical. There are several interrelated factors which affect the demand for commercial aircraft. Among these are: structure of the airline industry, airline profitability, interest rates, economic growth rates, airline regulation changes, safety and environmental regulations, and petroleum prices. In the past, competition among the airlines constrained airline industry profits and fostered excessive competition for new aircraft production. This led to excessive orders for new aircraft at the end of an economic expansion. The result was that the aircraft were scheduled to be delivered during the following recession. These factors will continue to vary with each business cycle and the political environment. They promise to keep commercial aircraft manufacturing an interesting business.

MILITARY FIXED WING SECTOR

Structure of the Military Fixed Wing Sector

The military fixed wing sector manufactures tactical aircraft which do not have commercial applications (SIC 37211 - military aircraft). The aerospace industry in the U.S. produces the majority of the world's premier military aircraft. This industry is comprised of a shrinking list of prime aircraft manufacturers due in large measure to the decline of the defense budget during the past ten years. Consolidations and mergers have occurred. The current prime airframe producers include Lockheed-Martin, McDonnell Douglas, Boeing, and Northrop Grumman. The merger of Lockheed and Martin Marietta in March of 1995 resulted in the world's largest military aerospace company. The purchase of Vought Aircraft Company by Northrop Grumman in 1994 is one more example of the consolidations occurring in this industry. Based on current and projected defense airframe contracts and the Department of Defense (DoD) procurement budget, the U.S. will have four recently designed military fixed wing aircraft in production at the end of the decade (excluding potential continued production of existing designs). McDonnell Douglas is manufacturing the F/A-18E/F (25% larger with greater fuel capacity than the C/D version), the T-45 (Navy primary and advanced jet trainer) and the C-17 (the only new military transport aircraft entering production). These aircraft will be joined by the winner of the Joint Primary Aircrew Training System (JPATS) competition. Lockheed Martin remains the prime contractor on the F-22, but funding delays have pushed production of this aircraft into the next century with an operational date planned around 2005 to 2010.

Reductions in defense spending are continuing to create a very challenging environment for the aerospace industry and particularly, the military airframe business. Defense budgets have been declining significantly since 1991 as a result of the demise of the Soviet bloc and a revision of threats to the U.S. national security. The approved DoD total obligation authority (TOA) for fiscal year (FY) 1995 of $250 billion is nearly $100 billion less than it was four years ago. Defense outlays as a share of the Gross Domestic Product are projected to be 3.5% in fiscal year 1996, which is almost half of what it was in 1980. Perhaps even more critical is the reduction in procurement expenditures, from a mid 1980s actual figure of $125 billion to less than $50 billion in currently planned expenditures in FY 1996. This represents only 15% of the defense budget versus nearly 30% in FY 1986. Additionally, the cutback in military force structure has been equally severe. Examples are readily seen in the reduction of aircraft carriers from 15 to 12 and Navy tactical wings from 15 to 11. Likewise, the number of Air Force fighter wings has decreased from 36 to 20 and the bomber force is going from 301 to 184 aircraft.

With these drastic cuts in defense spending, each military airframe company appears to be actively seeking both near and far term solutions to this current

downturn in the defense related industry. The centerpieces of these corrections in this strategic industry are cost reduction, production of prototypes, developing new defense or commercial business opportunities through "core" competencies and investing in technology to remain the world's leader in research and development. Because the procurement of military aircraft has seen a tremendous downturn from 337 in 1990 to a projected 46 in 1996, these aerospace firms have turned to concepts such as "lean" manufacturing or process improvements to remain in business. Most of these companies are not participating in the defense conversion scenario to commercial products, but rather are leveraging their unique skills to protect key capabilities such as systems integration and engineering design. This industry is also engaged in proposing revised defense related business ventures that include modifications or derivatives to existing aircraft.

With the B-2 production capped at only 20 aircraft, Northrop Grumman will cease to be a major manufacturer of large military aircraft and will focus on continuing their role as a significant subcontractor for Boeing's production of commercial aircraft and for McDonnell Douglas' F/A-18 aircraft. Also, as part of the Grumman takeover, Northrop acquired several ongoing modification programs such as the E-8 Joint Stars and upgrades to the F-14, EA-6B, and E-2C aircraft. The Navy is planning to purchase 28 new E-2C aircraft and appears to have Congressional support in this endeavor. Lockheed Martin will continue as one of the primary tactical aircraft manufacturers, producing F-16s at its Fort Worth plant for Foreign Military Sales after completing production for the Air Force and probably producing the F-22 in Georgia. The renowned Lockheed "Skunk Works" is actively involved in promoting an innovative proposal for a carrier version of the F-117 "stealth" aircraft to meet the Navy's deep strike requirements as a replacement for the retiring A-6 aircraft. In addition, the Palmdale facility continues modification and rework of the U-2/TR-1 and is in the process of reactivating several SR-71 aircraft. Lockheed Martin will introduce in 1996 a much improved version of the C-130H, the C-130J.

McDonnell Douglas Corporation is actively employed as a primary contractor for both the Navy and the Air Force, manufacturing the F/A-18C/D and initial production of the E/F model, T-45 trainer for the Navy, AV-8B for the Marine Corps, and the F-15E and the C-17 heavy lift long-range transport for the Air Force. The current cap on C-17 procurement positions the U.S. military with a significant shortfall in airlift capability beginning in 1996. There are several options or possibilities to fill this requirements gap, specifically with more C-17 aircraft, cargo versions of the Boeing 747, the remanufacture of the C-5, or a combination of these aircraft. Boeing is actively pursuing the military market with its 747 cargo aircraft and offering foreign markets an AWACS version of the 757 aircraft. Also, Boeing, as a partner in the teaming arrangement with Lockheed Martin on the F-22 is potentially positioning its military component for an increased share of future tactical aircraft programs. This opportunity may come with the development of the Joint Advanced Strike Technology (JAST)

program which combines many of the requirements of the Joint Strike Attack aircraft and the Advanced/Short Takeoff and Vertical Landing (ASTOVL) aircraft. Both the Air Force and Navy have demonstrated a need to replace their current inventories of aging fighter, attack, and multi-mission aircraft. But funding and eventual production will not likely be realized until 2010 to 2015.

Conduct of the Military Fixed Wing Sector

The downsizing of the defense budget continues to have a dramatic effect on not only the prime contractors, but perhaps even more so on the small businesses and second and third tier companies in the defense industrial base. This subcontractor level of production is experiencing a significant reduction in size with a potential loss of critical workforce skills and unique production capabilities. Some of this supplier reduction is due to planned management actions as firms move from a competition driven system of many suppliers to a quality driven system of long term relationships with fewer "preferred" suppliers. As an example, the supplier base for McDonnell Douglas has shrunk from over 7000 vendors in 1970 to around 2500 in 1994. In "necking down" the industry, the prime aerospace firms are implementing "lean" manufacturing processes which generate increased efficiency, reduced costs of operations and more affordable, higher quality products. With the production of the F/A-18E/F aircraft, McDonnell Douglas' "Phantom Works" is making a 25 percent larger aircraft with over 30 percent fewer parts than the original product. These improvement initiatives are also affecting the relationship with the lower tier structure. The prime contractors are incorporating certification and qualification programs to identify and subsequently contract with their primary "preferred subcontractors." As a result, many firms have been forced to convert to non-defense products, consolidate with other similar companies, or go out of business. In some cases, the primes are buying smaller companies to protect certain product lines or valuable pieces of equipment. The numerous challenges for the entire industry are focused on remaining competitive, both domestically and internationally. Streamlining manufacturing processes has changed the way of doing business for most of the prime contractors, including domestic and international companies. "Just in time delivery," low production rates and bringing work "in house" are some of the major changes made by the global primes which have severely hampered the ability of the smaller firms to remain in business. An additional factor complicating the situation for the smaller subcontractors is the advent of high speed, computerized machines requiring large commitments of capital.

Employment figures for the global military fixed wing aircraft industry reflect the familiar theme of self-correcting and reducing in size. In the U.S., employment the military aircraft sector fell by 19,000 workers in the past year to 229,000. From a high of 401,000 in 1986, the industry appears to be heading even lower in 1995 to an estimated 212,000 employee workforce. In Europe, British Aerospace Defence Limited (Military Aircraft Division) has reduced from 16,000 to 3,500 employees while

Dassault Aviation in France has declined from 16,200 in 1984 to 9,400 in 1994.

The competition to the U.S. military fixed wing aircraft industry in Europe is pursuing a different course of action in industry's approach to producing new and improved tactical aircraft. British Aerospace, Daimler-Benz, Casa, and Fiat have united to produce the Eurofighter 2000. This consortium, through investments from their governments, own or control most of the lower tier manufacturing. They believe the potential for the EF 2000 is very encouraging, with sales to the partner countries and analysis of the prospect for exports strong enough to move forward with the program. France's Dassault Aviation is currently developing the Rafale to meet their French future fighter/attack requirements, with an Initial Operational Capability (IOC) in 1997. While the French government fully funded this program in the past, Dassault was forced to fund part of the development to keep the project alive during a period of declining French defense budgets. The key issue for France and Dassault is how well the aircraft will compete in the export market--the only chance for realizing a profit on this capital intensive development and production program.

Performance of the Military Fixed Wing Sector

The military aircraft industry, in particular, has suffered tremendously in the era of declining defense budgets. But even with this decline in procurement, the military sector in 1994 was once again the aerospace industry's largest product segment, a reversal of the previous two years when civil aircraft production pulled ahead of defense or military sales. Military aircraft procurement for the U.S. has decreased from 337 units in 1990, to 55 in 1995, and will fall to 46 in 1996. Most of this decline has been in the fixed-wing aircraft arena. U.S. military aircraft manufacturers shipped $32 billion in sales in 1994 and forecast a decline of 3 percent, or $1 billion, in 1995.

The Foreign Military Sales (FMS) program historically represented about 20 percent of U.S. military aircraft sales, but the number of FMS military aircraft shipments fell by nearly 50 percent in 1994, down to $770 million due to a reduction in sales of fighter aircraft. FMS of tactical aircraft peaked in 1992 at $1.3 billion following the Persian Gulf War, but declined 41 percent in 1993 and another 82 percent in 1994. Thus, U.S. FMS cannot be relied on to completely offset the loss of domestic procurement.

Stiff international competition exists for future U.S. FMS offerings. The Eurofighter 2000 consortium is banking their future on the improved technology of their dual mission fighter. Unknown at this time are the number of units that will be produced, either for the member countries or for export sales. A direct European competitor is the Rafale, which is presently well into production. Firm commitments from the French government for 250 Air Force and 84 Naval Rafale aircraft from the same basic design provide the base for this stealthy, advanced technology, multi-

mission fighter. In the global market, roughly two-thirds of each European military fixed wing company or consortium's revenue business is planned for exports.

While U.S. procurement budgets have declined 50 percent over the past ten years, total research and development(R&D) funding has remained relatively stable. This stability in R&D has been the only encouraging aspect in the U.S. defense industry. It has allowed the continued development of advanced technologies in military airframes and weapons systems. The UK is proceeding along a different track by favoring defense procurement expenditures while decreasing research and development. The French, however, appear to be dedicating research funds at a rate that will sustain new technology development and continue their ability to compete in the global market.

HELICOPTER SECTOR

The helicopter market, though smaller than the fixed wing markets, has the same issues as the other aircraft sectors. There is vigorous competition for the 700 to 800 aircraft a year helicopter market. Generally, helicopter manufacturers are either high technology military helicopter companies or price competitive, stable, second generation helicopter firms oriented to the civil sector.

Structure of the Helicopter Sector

Four elements defining the helicopter sector must be considered: (1) airframe weight classifications; (2) purchasing sectors; (3) significant manufacturing companies; and (4) barriers to market entry.

Helicopters are classified by their maximum gross take-off weight (MGW) in pounds. Most military helicopters are medium lift or heavy lift, with few in the light category, and none in the small category. Civil helicopters are predominantly of the light category. Each category has distinctions in terms of engineering and technical expertise required, factory machining and tooling required, aircraft cost, and market served. There are approximately 25 different light models, 13 medium, and 3 heavy helicopters.

The world's helicopter inventory in 1994 was approximately 41,900 aircraft. Civil sector helicopters included 11,400 aircraft and the military sector contained 30,500 aircraft worldwide. The civil sector is very diverse with operators ranging in size from one helicopter (over one third of the operators) to some operators with over 100 helicopters. Civil applications require helicopters which are simple; low in application cost; have high payloads; low operating costs; rapid spares response; and high reliability. The normal purchase price for a new helicopter in the civil market is $700,000 - $4,000,000. Two of the four major DoD helicopter firms are active in the

domestic civil market. The very nature of combat operations drives military designs to more robust, heavier, damage tolerant aircraft that are more complex, expensive, and less efficient than those required for commercial applications.

The U.S. helicopter sector has an oligopoly structure with four firms accounting for greater than 95% of turbine powered helicopter sales. All major U.S. helicopter firms except Bell Helicopter rely on DoD for the majority of their total revenue and are not major players in the civil market. Each of the major firms are subsidiary companies within large conglomerates and include:

- Bell Helicopter Textron, Inc. (BHTI), Ft. Worth, TX.
A division of Textron.
- Boeing Helicopters, Philadelphia, PA, of the Defense and Aerospace Group of Boeing Aircraft Company.
- McDonnell Douglas Helicopter Systems (MDHS), Mesa, AZ.
A division of McDonnell Douglas Aerospace Company.
- Sikorsky Aircraft Corporation, Stratford, CT.
A division of United Technologies.

Several of these U.S. domestic manufacturers have entered teaming arrangements for development and anticipated production of major new helicopter programs. These include: Boeing and Bell for the V-22 "Osprey," Sikorsky and Boeing for the RAH-66 "Commanche," and McDonnell Douglas, Lockheed-Martin, and Westinghouse for the AH-64D "Longbow." In addition, American Eurocopter, Enstrom, Kaman, Robinson, and Schweizer are five non-DoD dependent helicopter manufacturers in the U.S. domestic market. These companies make small and light (2-4 person) helicopters.

There is considerable foreign competition in the helicopter sector. Leading Non-U.S. based manufacturers include Agusta (Italy), Eurocopter (France and Germany), and Westland (Britain). Other firms providing meaningful helicopter production include Kawasaki and Mitsubishi (Japan), MilDesign (Russia), Singapore Aerospace, and China National Aero-Technology. Several of these companies have teamed in joint partnerships for production of new helicopter market entries. They include: Agusta and Westland in "European Helicopter Industries" (EHI), producing the new medium utility EH-101, and Augusta, Eurocopter, and Fokker producing the NATO NH-90 helicopter. Singapore Aerospace, China National Aero-Technology, and Eurocopter are teamed to produce the EC-120, a light utility helicopter. In October 1994, Eurocopter, Mil Design, Kazan and Klimov created a joint venture company, called Euromil, to develop, produce and market the Mi-38 (30 passenger). Eurocopter predicts the MI-38 will capture 75% of the rapidly expanding CIS civil freight and energy market. The 1994 market revenue shares of the major helicopter manufacturers are depicted in Table 2. This table also depicts market shares without the U.S. military market. Comparison of these figures readily indicates the most likely

firms to weather the storm of deepening defense cutbacks and cancelled DoD contracts.

Company	Market Share Including U.S. Military Market	Company	Market Share Without U.S. Military Market
Sikorsky	27 percent	Sikorsky	10 percent
Eurocopter	22 percent	Eurocopter	18 percent
Bell	16 percent	Bell	20 percent
Boeing	15 percent	Boeing	13 percent
McDonnell Douglas (MDHS)	9 percent	MDHS	16 percent
Agusta	6 percent	Others	23 percent
Westland	5 percent		

Table 2: Market Shares of World Helicopter Manufacturers

Capital investment and the development of technical expertise are significant barriers to entry into the helicopter industry. Large capital investment is typical of aerospace firms. The dynamics of a rotating mass requires specialized technical expertise that is not available at fixed wing aircraft manufacturers and presents numerous challenges peculiar to helicopters which require special designs, particularly for helicopter dynamic components. Helicopter unique design and development requires expertise that flows from many years of experience available only in existing helicopter companies.

Conduct of the Helicopter Sector

In addition to dramatic reductions in DoD budget authority for procurement, the trend in DoD helicopter acquisition is toward smaller numbers of higher unit cost systems that incorporate technologies such as stealth, advanced sensors, and advanced fire-control systems. Traditionally, each of the four major U.S. domestic helicopter manufacturers satisfied a specific sector of the market with either unique size or performance characteristics of their product not offered by a competitor. However, the landscape is changing in the product mix of these companies as evidenced by the teamings/partnerships mentioned earlier. The motivation is most closely tied to the nearly 60 percent decline of U.S. military procurement of new helicopters from a total sales value of $3.7 billion in 1992 to a projected value of only $1.5 billion in 1996. All major U.S. manufacturers are attempting to respond to diminished defense revenues and are actively pursuing variations of their product lines

to compete credibly in the expanding international civil and military markets. The commercial helicopter market has been "old turf" for some U.S. helicopter manufacturers, and may be a "new lease on life" for others. Bell Helicopter is the only major U.S. firm to obtain the majority of their revenue from the sale of civil helicopters.

Performance of the Helicopter Sector

It is routinely concluded and recognized that the helicopter industry has excess capacity, thereby making it a business challenge to keep the employed capacity productive, if not profitably utilized. Efficiency and productivity have been the watchwords from every boardroom to each employee. Bell Helicopter, however, is the only major helicopter company to add employees in the last year. Given a moderate growth in revenue due to the large V-22 program, Bell may emerge as the largest U.S. helicopter company. Other companies have been hard hit by U.S. Government decisions to cancel major programs, such as the RAH-66 Commanche and the Army and Navy H-60 Black Hawk/Sea Hawk. DoD's curtailed procurement which will now crest in 1997 of the H-60 and RAH-66 exacerbates helicopter industrial base concerns. Defense Secretary William Perry told the Senate Armed Services Committee there is enough work to sustain a viable helicopter industrial base up to that time. But he said the Pentagon faces a "substantial problem" after 1997 when production of the UH-60 Black Hawk for the Army ends. "We don't have a solution in hand for that." These comments were made before the cancellation/adjustment to the Commanche program was decided. It is a tone that signals an "every man for himself" industry environment. It is a widely held view among industry experts that, regardless of the initiatives individual companies take to remain in the market, the greatest efficiency will come with merging or outright withdrawal from the market.

Despite this gloom, there are bright spots in today's helicopter sector as well. Most notably, the V-22 program for the Bell-Boeing team's production of approximately 530 Ospreys for the U.S. military. Additionally, sales of the V-22 on the international military market are estimated at 250-600 over the next 20 years, without any estimate yet for potential civil application purchases. The civil rotorcraft market is leaning more toward a higher percentage of twin-turbine helicopters, as opposed to light single-turbine aircraft. The value of U.S. turbine-powered civil helicopters shipped in 1994 jumped 51% to $171 million from a record low in 1993. Such a turnaround is hopefully indicative of the market opportunities such helicopters as the Bell 430, the MD-900/901 "Explorer", and the Sikorsky S-92 can take advantage of worldwide in head-to-head competition with European and Asian competitors.

Helicopter sales trends, in terms of units delivered, are expected to move downward through the year 2004. However, it is anticipated that the sales value of these annual deliveries will generally increase over the 10-year period, due to the market entry of such relatively expensive rotorcraft as the V-22 and the EH-101. The

total commercial helicopter market for the 1995-2004 time frame is projected at approximately 9,150 units valued at approximately $22.0 billion in 1995 U.S. dollars. The projected growth in annual unit production over the next 10 years is much less pronounced than the projected value of that production, due largely to the increasing market share of relatively expensive multi-engine turbine helicopters.

In the future, helicopter firms will seek to realign their market shares by fielding new/enhanced products for the commercial market sectors. Consolidation, alliances, teams, partnering, and consortia will seek to provide access to both domestic and international markets, while reducing risk incurred due to new technology and uncertain world economic fortunes. The industry will seek to loosen restrictions that hinder foreign military sales or international sales volume to fill gaps caused by the severely curtailed U.S. DoD customer and buy time to shift gears to commercial market applications. Helicopter firms will pursue greater efficiencies in processes and overhead reductions, and seek to optimize applications for dual use technologies for which the helicopter is a superb candidate.

AIRCRAFT ENGINE SECTOR

Structure of the Aircraft Engine Sector

There are currently 18 jet engine manufacturers, excluding the former Soviet Union. Of these, Pratt & Whitney (U.S.), General Electric (U.S.), and Rolls Royce (UK), and SNECMA (France) account for 80% of market share. Second tier manufacturers and a large network of subcontractors and vendors round out the aircraft engine industrial system.

Alliances, consortia, joint ventures, and mergers, including both domestic and foreign manufacturers, dominate market strategies. For example, on 24 March 1995, Rolls Royce completed the $525 million acquisition of the U.S. Allison Engine Company. Overcapacity, prohibitive development costs (as much as $1.5 billion for a new jet engine), and limited sales profiles have led to a maze of interlocking relationships with shared responsibilities for research and production. U.S. firms participate fully; however, anti-trust laws limit these ad hoc partnerships.

Conduct of the Aircraft Engine Sector

Engine makers have suffered a double blow in the past few years. On one hand, the military jet engine business has shrunk drastically, and at the same time a prolonged slump in the airline industry has shriveled commercial sales, with aircraft deliveries falling to 478 last year from a peak of 844 in 1991. For engine makers, this slump has been devastating. Four years ago, Pratt & Whitney made 800 commercial engines, and this year it will make 400.

Affordability is the key to global competition. Engine manufacturers are restructuring to reduce costs, improve cycle time, and incorporate lean manufacturing techniques. General Electric (GE) has reduced the order-to-delivery time by 50%. Unfortunately, streamlining has translated into huge job losses. As an example, Pratt & Whitney cut employment to 30,000 from 50,000 five years ago.

Performance of the Aircraft Engine Sector

After nearly three years of sharply declining earnings, aircraft engine makers see signs of recovery. But there is little rejoicing in an industry not expected to reach its former size anytime soon. The need to replace aging equipment, stricter noise requirements, a growing Asian market, and a rebounding airline industry portend future growth. As an example, last year the world airline industry recorded its first annual profit since 1989 ($1.8 billion).

The military sector is less promising. Uncertain threats, reduced procurement budgets, and deficit reduction initiatives point to declining defense requirements. Only two U.S. designed fighter engines will be in production after 2000, and bomber engine production will cease after 1998. As a hedge against reduced sales, engine makers are showing renewed interest in overhaul and repair of military engines. This interest has heightened the debate between keeping an organic, depot-level maintenance capability in the military and providing enough business to commercial engine makers to keep them viable.

In any event, export sales will be critical to preserve a U.S. engine manufacturing base. The U.S. presently exports over $4 billion in aircraft engines and engine parts. GE aircraft engine export sales already account for 50% of the company's business.

Competition remains fierce. Pricing pressure and the need to sacrifice profits to launch new engine programs will characterize the industry in the future. While engine makers regularly join forces to share costs today, eventually such relationships could make the engine makers more inclined to think about outright mergers.

INDUSTRY STRATEGIES FOR SURVIVAL

Given the decline of purchases for both military aircraft and commercial transport aircraft, competing firms must take positive action to protect shareholder value and ensure corporate survival. A number of potential strategies have been identified. As a first option, firms may elect to shut down their unprofitable business units. Examples of this are LTV's exit from missiles and aircraft and Lockheed's exit from the large commercial transport market. A second option is that firms may elect to strip down their operations to remain profitable. Many firms have significantly reduced the size of their operations. Boeing eliminated 40,000 jobs between 1991

and 1994, announcing another 12,000 person reduction in May 1995. McDonnell Douglas eliminated 60,000 defense jobs since 1990. The third option is for firms to sell assets, thus creating a more focused company. Examples of this strategy include the sale of General Dynamic's military aircraft business to Lockheed in 1992 and the sale of Ford Aerospace to Loral in 1992. The fourth option is for firms to swap or merge assets to form a market leader. Examples of this strategy include the European merger of MBB and Aerospatiale to create the $1.5 billion Eurocopter and the merger of Lockheed and Martin-Marietta to form a $23 billion corporation. For another alternative, firms may decide to spin off pieces of their business to form stand alone business activities. This strategy has been pursued in Europe by British Aerospace by the establishment of a separate firm to produce military aircraft software systems. Defense firms may attempt to diversify their product lines and focus upon non-defense products. This is possible for firms which participate in both defense and civil markets, and may be appropriate for manufacturers in the U.S. helicopter industry. Aircraft firms are also reducing risks on existing and future projects. Almost all firms now seek risk-sharing partners for the development, manufacture, and sales of aircraft products. Some firms participate in consortia and desire formation of long term strategic alliances, while other firms prefer to establish partnerships on a project by project basis. In either case, the objectives are to spread risk among the partners, tap each other's strongest resources, and obtain access to broader markets. Keys to corporate survival will include continued product innovation and cost reduction while continuing to deliver high quality goods and services.

GOVERNMENT POLICY OPTIONS

Sustainment of a Domestic Industrial Base

Given smaller worldwide defense budgets, nation-states are finding it much more difficult to sustain a completely domestic defense industrial base. The British, who are involved in developing the Eurofighter, and the French, who are developing the Rafale, do not believe they will pursue separate programs to develop tactical aircraft in the future. The U.S. Government can aid the sustainment of a domestic industrial base by recognizing shared risk as a survival strategy and removing remaining barriers to joint ventures and consortia within the defense industry. Additionally, the U.S. Government should consider the industrial base implications of co-production and offsets. Although they increase sales, maintain production rates, and lower costs to the DoD, they erode an already reduced vendor base for key components. The transfer of components away from domestic producers is detrimental to the domestic aircraft industrial base.

The U.S. Government deals directly with the major prime contractors and for this reason has a good appreciation for the first tier of the industrial base. However, because it does not always deal directly with the lower tiers, the government's knowledge of the subcontractor and component vendor base may be inadequate to

sustain key technologies. The government should consider the development of an oversight council in partnership with industry to monitor the sub-tier suppliers critical to the defense industrial base.

The domestic helicopter manufacturing base appears particularly threatened, and the uncontrolled sale of excess military helicopters will not aid this situation. The government should develop a plan for the reuse, storage, or disposal of excess military helicopters to balance possible government revenues with the health of the domestic helicopter manufacturing base. Long term storage, rather than resale, of excess military helicopters, while potentially reducing government revenues, would help sustain the domestic helicopter manufacturing base.

Finally, the Federal Government should pursue civil military integration (CMI) and forge, to the maximum extent practical, a single national industrial base. Efforts which will aid CMI include the elimination of military specifications, acquisition of commercial products or modified commercial products whenever practical, and greater reliance on commercial contracting practices. Transition of depot maintenance work from government to industry will also assist the development of an integrated industrial base. CMI will increase affordability by eliminating the inefficiencies of separate government and commercial practices.

Communication with Industry

It is clear that many segments of the aircraft manufacturing industry, particularly for military aircraft, have capacity far greater than anticipated near term demand. Under these conditions, some industry consolidation is inevitable. But to establish an efficient industry structure, the government must clearly communicate its anticipated future requirements in order for industry to appropriately consolidate. The helicopter sector appears particularly threatened. The joint development by industry and government of a strategic plan for development and use of rotorcraft in this country may assist consolidation. Such a national effort should include all infrastructure features necessary for continued access and to further utilize the flexibility and versatility of this national resource.

Maintain a "Level Playing Field" for International Trade

The commercial aircraft industry has important synergies with national defense. The establishment of an adequate aeronautical science and engineering technology base could become a valuable time saving component in any national mobilization effort. The commercial aircraft industry provides an ideal vehicle for retaining an aeronautical engineering technology base during times of relative peace. This synergy with defense and other high technology industries has made the aircraft industry a target of national strategies. The successful establishment of Airbus Industrie's market position within the commercial aircraft sector can be viewed as the fulfillment

of national strategic goals on the part of the European participants. The same characteristics which made the commercial aircraft industry attractive to Europe may make it attractive to other nations in the future. Continued government intervention in this industry will remain likely in the future.

The maintenance of a level playing field for international trade is complicated by many issues other than the synergy between commercial aircraft and defense. Varying national tax structures vary, provide incentives and disincentives for particular industries. For example, differences in petroleum and aviation fuel tax rates affect profitable aircraft operations. Additionally, some governments own their aircraft manufacturers and may attempt to maintain employment during market downturns. It is also possible to support aircraft manufacturers by supporting the firms which use their products, such as state owned airlines. These differences, coupled with changing market positions caused by changes in international currency valuations and differing corporate capabilities, will make it problematical to define a "level playing field."

The U.S. government must continually assess its international political policies which impact U.S. firms in their ability to compete in world markets. Sanctions, while used as a political tool, have often proven to be ineffective and counterproductive to the U.S. economy. A prime example is the potential Chinese helicopter market where Sikorsky and Boeing are currently prohibited by U.S. policy from selling their large military helicopters well suited to the market. Eurocopter is actively establishing itself in this area, and there is serious concern that U.S. firms will lose the opportunity to compete.

Technology Development

The National Aeronautics and Space Administration (NASA) invests in higher risk, long term payoff technologies in which it believes industry would under invest. NASA's 1996 aeronautics research budget of $912 million includes funding for high performance computing, numerical aerodynamic simulation, high speed research, and advanced subsonic technology. The high speed research program examines the environmental impact and economics for the high speed civil transport program, a supersonic commercial transport with a potential for $200 billion in sales in the next century. This NASA support will position the U.S. to take a leadership position if a commercial high speed transport can be economically developed. NASA's advanced subsonic technology program is focused in four areas: aircraft safety, the environment, air transportation system capacity, and aircraft economics. Efforts in advanced subsonic technology could lead to more efficient wing designs, composite primary structures, and noise and emission reductions. This government investment provides indirect support for the aircraft industry and helps to manage the playing field for international trade.

Military engine development requires engineering expertise in technologies which are not common to commercial engines. These technologies include signature minimization for low observability and thrust vectoring for high maneuverability. To sustain the military engine sector, the Department of Defense should continue to pursue research in military engine technology, as well as develop modifications to existing inventory engines. Innovation has provided U.S. engine manufacturers a comparative advantage since WWII. Continued R&D funding is critical to maintaining that advantage.

Cost Reduction

The government has a major concern with the increasing cost of tactical aircraft. In an effort to work with manufacturers to reduce costs, the government has participated in the Aircraft Lean Manufacturing Initiative along with the Massachusetts Institute of Technology and U.S. aircraft manufacturing firms. The tactical aircraft producing sector may consolidate to only two firms. If the government desires to retain multiple contractors in this sector, future contracts will need to be spread among existing firms to ensure their survival. This action may inhibit market forces and likely hinder the adaptation and adoption of cost cutting manufacturing technologies. Therefore, the government needs to accept a partnership role with industry if manufacturing cost reductions are to be achieved. Continuing the Aircraft Lean Manufacturing Initiative is one method for government to influence aircraft manufacturing cost reductions.

Investment in Infrastructure

The National Aeronautics and Space Administration believes the airline industry wastes $3.5 billion annually due to airport delays. Government investment in the national airspace management infrastructure could reduce this waste, help to improve airline profits, and allow for the purchase of new aircraft.

Promotion of Foreign Military Sales / Direct Military Sales

The decreased international military tension at the end of the Cold War predictably reduced the domestic demand for U.S. produced weapons systems. Under these circumstances, foreign sales have become more important for the maintenance of the U.S. industrial base. Through the year 2000, the potential market for foreign military aircraft sales and upgrades exceeds 1900 systems with an estimated value of $90 billion. FMS both lowers the unit costs of future systems acquired by the U.S., and allows the industry to maintain production lines long after U.S. Government procurement is insufficient to maintain economic production. FMS has sustained production of both the F-15 and F-16, and this recently allowed the U.S. to purchase additional F-15E aircraft without costly and time-consuming production startups.

The U.S. share of worldwide military exports has steadily increased from 19 percent in 1987 to 53 percent today, and it is expected to climb to 70 percent in the future. Key reasons for the success of U.S. military products have been: interoperability, quality, leading technology, competitive pricing, outstanding training and service, and long standing buyer-seller relationships. The U.S. continues to aggressively pursue FMS through the negotiation of not-to-exceed fixed price contracts as demonstrated in the recent Netherlands helicopter competition between the U.S. produced Apache and the Eurocopter produced Tiger. During worldwide defense downsizing, the U.S. should continue to use FMS to sustain its industrial base while guaranteeing the future security of its allies.

CONCLUSION

The aircraft industry remains strategic. It continues to be a major positive contributor to the U.S. balance of trade. This industry employs a significant numbers of scientists and engineers while providing many high wage manufacturing jobs. Aircraft are a key component in many developed countries' defense strategies, and many countries consider participation in the aircraft industry a matter of national prestige.

The U.S. no longer dominates the aircraft industry. Powerful foreign competitors have risen in commercial aircraft, military fixed wing aircraft, helicopters, and aircraft engines. Foreign state-of-the-art firms and consortia such as Airbus, Aerospatiale, British Aerospace, Dassault, Eurocopter, Rolls Royce, and SNECMA have technical capabilities equal to those of U.S. firms. Competition can be expected to intensify as the defense related sectors of the industry continue to rationalize. In order to survive, firms must continue to innovate, improve quality, and reduce development cycle times while reducing costs.

The U.S. Government can assist the industry through this transition by: promoting a level playing field for international trade, supporting aeronautical technology development, and providing stable defense procurement plans which foster integration between the commercial and military industrial bases. Proper U.S. Government policies and involvement can help sustain U.S. leadership in this strategic industry.

BIBLIOGRAPHY

1. 1995 Helicopter Annual, Helicopter Association International, 1995, p.14.

2. "Consolidation of the Helicopter Sector Near?," Interavia, January 1995, p.25.

3. "Navy H-60 Cuts Pose Industrial Base Issue," Aviation Week & Space Technology, Feb. 14, 1994, p.25.

4. "Group Markets V-22 in Japan," Defense News, Feb 20-26, 1995, pp. 28-29.

5. "MD-11 Production to Hit 30-35 in 1993," Aviation Week & Space Technology, Oct. 25, 1993, p. 24.

6. Aerospace Facts & Figures 1993-1994, Aerospace Industries Association of America, Inc., Washington, DC, 1993, pp. 10-162.

7. Banks, Howard, Superjumbo, Forbes, 24 Oct 94, p.182.

8. Compact Disclosure, CD-ROM Database, Disclosure Incorporated, 1993.

9. Dertouzos, Michael L., Richard K. Lester, and Robert M. Solow, Made in America, MIT Press, 1989, pp. 24-203.

10. International Trade: Long-Term Viability of the US-European Union Aircraft Agreement Uncertain, U.S. General Accounting Office (GAO), Report GAO/GGD-95-45, Gaithersburg MD, December 1994, p.12.

11. Napier, David H., 1994 Year-End Review and Forecast, Aerospace Industries Association, Inc., Washington, DC, pp. 2-4.

12. Proctor, Paul, "Boeing Rolls Out 777 to Tentative Market."
13. Aviation Week & Space Technology, April 11, 1994, p. 39.

14. Sparaco, Pierre, Airbus Chief Sets New Course, Aviation Week and Space Technology, 23 Jan 95, p.52.

15. Standard and Poors Industry Surveys, Aerospace & Air Transport Basic Analysis, Vol. 162, No. 26, Sec. 1, Jun 30, 1994, pp. A17-A19.

16. U.S. Industrial Outlook 1994, U.S. Department of Commerce, Government Printing Office, Washington, D.C., pp. 20-2 - 20-9.

17. Yang, Dori Jones, Stewart Toy and James Ellis, "The Hint of an Updraft," Business Week, June 20, 1994, p. 66.

INDUSTRY STUDY

#5

BIOTECHNOLOGY

TABLE OF CONTENTS

PARTICIPANTS

Students

Dave Anderson

Jimmy Ng

Jim Butler

Marie Rowland

Joe Frizzel

Ken Schor

JP Galligan

Dave Temp

Gary Kyle

Sid Tronic

Chris Liebengood

John Whitmor

Dave Little

Victoria Yourkavitch

Donita McGeary

Bob Yuill

Faculty

Dr. Rita Wells

CAPT Dan McElroy

Dr. Gerry Berg

PLACES VISITED

Domestic

U.S. Dept. of Agriculture
Smithsonian Institute
Natick Army Laboratories
U.S. Patent and Trademark Office
Armed Forces Institute of Pathology
U.S. Army Research Laboratories,Fort Dioptric, MD
Joint Program Office for Biological Defense
FBI Forensic Laboratory
National Institutes of Health
University of Maryland
University of Connecticut
Georgetown University
Harvard University
Tufts University School of Veterinary Medicine
Massachusetts Institute of Technology
Ernst & Young, LLP
Genzyme Corporation
Human Genome Sciences
GelTex Corporation
Biotechnology Industry Organization (BIO)
Massachusetts Biotechnology Research Institute
Peter Feinstein & Associates

International Travel

German Cancer Research Center, Germany
Cambridge University, United Kingdom
Delft University of Technology, Netherlands
University of Heidelberg, Germany
Oxford University, United Kingdom
Oxford Molecular Corp., United Kingdom
Christian Hansen, Denmark
Novo Nordisk, Denmark
SmithKline Beacham, Belgium

BIOTECHNOLOGY: ENORMOUS POTENTIAL FOR THE FUTURE

Biotechnology is the application of biological knowledge and technical skills to produce useful products and services. It has developed as an industry only within the last 15 to 20 years, but already has many and varied applications and will probably grow continuously for the foreseeable future. Its potential effects on how we live and our economic well-being are enormous.

In this report, we review the development of biotechnology as a science and as a viable commercial industry, describe its applications, identify obstacles that could impede its continued growth and prosperity, and discuss ethical and public policy issues. We conclude that biotechnology has great strategic potential for the U.S., and that the Federal Government has a role to play in enabling its development and ensuring that its ethical issues are adequately addressed.

INTRODUCTION/BACKGROUND

Recognizing that many people have little knowledge regarding the biotechnology industry, we use this section of the report as a primer. We do so by addressing in more detail what biotechnology is, its scientific foundation, and the nature of the work that biotechnologists do. We leave for the next section a description of the biotechnology industry in terms of its structure and size.

What Is Biotechnology? The term "biotechnology" comes from the Greek "bios-tekhne-logos, " meaning "the study of the manipulation of life." Broadly defined, biotechnology is the manipulation of living organisms and life processes to produce useful products or services. Biotechnology does not represent a product category, per se, but rather a set of processes or techniques that are based on an integration of biological knowledge and other technological expertise. Within the framework of this general definition are all forms of biologically based activities, including such traditional activities as cheese making, beer brewing, and animal husbandry. More applicable in today's environment, the term "biotechnology" refers to processes that embrace all of the genetic modification techniques of modern molecular biology as well as other modern developments associated with "traditional" biotechnological processes.1 Throughout this report, the term "biotechnology" is intended to refer to biotechnology in the modern sense. Similarly, the biotechnology "industry" is intended to refer to all of the companies that are using modern biotechnological processes, even though the nature of their products and services vary widely and, technically, may be subsumed under other industries (e.g., the agriculture or pharmaceuticals industries).

History and Underlying Science. Modern molecular biology began in earnest after World War II as scientists gained increasing knowledge regarding deoxyribonucleic acid (DNA), the substance which serves as the master architect of

life and is contained in the cells of all living organisms.2 In 1953, Drs. Watson and Crick, at Cambridge University, identified DNA's structure. Over the next 20 years, scientists determined how DNA functions and, in 1972, performed the first successful DNA cloning experiments.

Data stored in a cell's DNA determine how the cell functions and carry the coded messages of heredity for future generations. DNA is a polymer consisting of subunits, called nucleotides, which contain a sugar (deoxyribose), a phosphate, and one of four different bases. The four bases, each represented by a letter, are: adenine (A), cytosine (C), guanine (G), and thymine (T). The DNA "ribbon" consists of two matching strands twisted into a spiral--the famous double helix. The twin strands are connected by pairs of the bases, but, because of the shape of the structures involved, a G can only link to a C and an A can only link to a T. As a result, the DNA of the two strands is necessarily complementary. This ensures that when the two DNA strands separate during cell reproduction, they form new double helixes in their new cells that contain DNA identical to the DNA in the original cell.

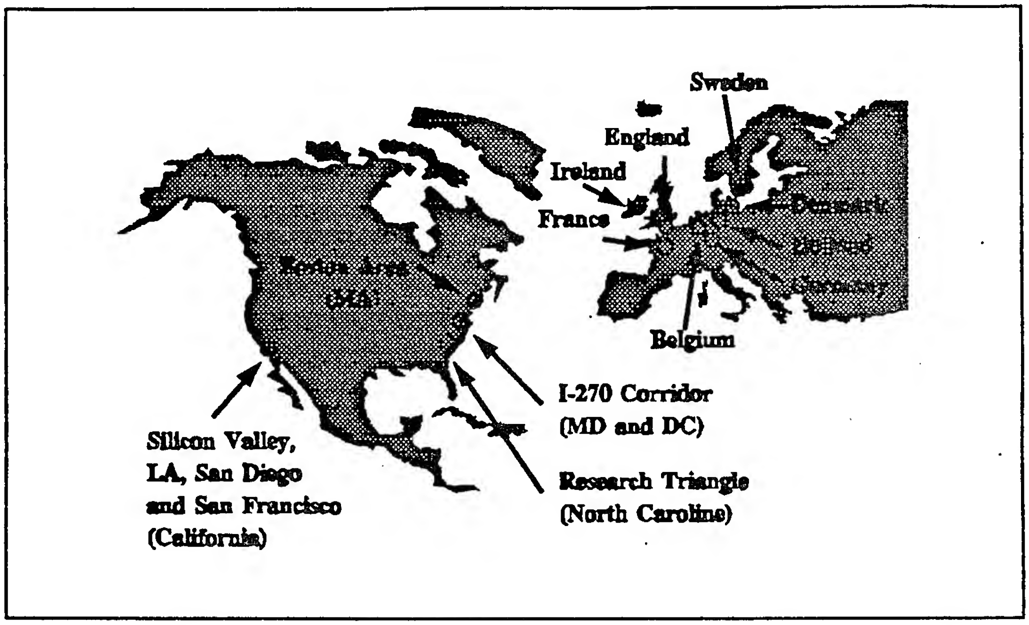
DNA is grouped into portions that encode for a single protein or protein subunit called a polypeptide. These groupings are individually known as genes. All cells in an organism contain the same genes, which collectively are referred to as the organism's genome, but different genes actively function in different cells. This "expression" of genes in different cells results in the cells having different structures, compositions, and functions.

What Do Biotechnologists Do? Much of modern biotechnology is concerned with identifying and, in some fashion, using individual genes that are responsible for an organism's production of specific proteins or polypeptides. Scientists and companies engaged in biotechnology employ a number of modern processes including recombinant DNA, cell fusion, and novel bioprocessing techniques.3 In some cases, the objective of their efforts may be to produce a protein in large quantities for commercial application. This is true, for example, with certain enzymes (proteins that catalyze chemical reactions) that improve the performance of commercial detergents. In other cases, the objective may be to transfer a gene from one type of plant or animal to another in order to improve some characteristic. This might be done, for example, to increase the pest or rot-resistance of a food crop. In still other cases, the objective of a biotechnology effort may be to insert a functioning gene into an individual with a defective gene to permit the individual's body to produce a required protein. This is a form of "gene therapy" and was successfully used in a few cases at the National Institutes of Health (NIH) to cure qenetic diseases.

THE BIOTECHNOLOGY INDUSTRY

The biotechnology industry is diverse and widespread. It consists of approximately 3,000 business entities in a number of developed countries. These

range from very large pharmaceutical giants of the health care industry, some major oil companies, and other large multinational corporations to some very small, closely held companies, that only do biotechnology-related research and development work at this time. The biotechnology-only companies are clustered primarily in the regions shown below. A broad range of academia, industrial associations, and qovernment organizations support the industry.



In 1994, there were an estimated 1,311 companies in the U.S. engaged only in biotechnology work. These companies are often referred to as dedicated biotechnology companies. About 68% of them are involved with developing or producing pharmaceutical or diagnostic products, 15% with supplies for the biotechnology industry, 9% with chemical or environmental products and services, and 8% with agribusiness products. Only a small percentage of the dedicated biotechnology companies have products on the market and, therefore, have a steady revenue stream. Approximately one-half of the total market value of these companies lies in the top 20 companies. The following chart sets forth 1994 market value and sales data for some of the largest dedicated biotechnoloqy companies with products on the market.4 Their products in all cases are pharmaceutical drugs or medical products.

Company	Market Value ($M)	Sales ($M)	Net Income ($M)
Amgen	$5,704	$1,306	$383
Genetech	5,678	457	59
Chiron	1,802	148	18
Biogen	928	136	32
Genzyme	636	234	(6)
Immunex	499	119	(430)

The remaining dedicated biotechnology companies, about 95% of the total, are essentially research organizations attempting to complete development of products. Generally, for the first 7 to 10 years of their existence (or longer) they lose money. Rather than referring to their profit rates, these companies refer to their "burn" rates, or the rate at which they are spending funds. Their total available funding divided by their burn rates equals their "survival" time. In its 1995 annual report on the biotechnology industry, Ernst & Young LLP calculated an average survival time of 25 months for dedicated biotechnology companies, a decrease of 9 months from the previous year.5 As discussed in more detail below, availability of funding is perhaps the most critical issue facing most of the U.S.'s dedicated biotechnology companies at this time.

In contrast with the dedicated biotechnology companies, companies doing more than just biotechnology tend to be larger firms concentrated in the pharmaceutical and chemical industries. They have access to sufficient financial resources to remain financially stable as they develop biotechnology products.

The major U.S. Government organizations directly participating in efforts to advance biotechnology are the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Department of Agriculture (DoA). The Department of the Interior (DoI), the Department of Energy (DoE), and the Department of Defense (DoD) are funding modest R&D efforts. Other government organizations whose activities directly influence the biotechnology industry include the Food and Drug Administration (FDA), the Patent and Trademark Office (PTO), and the Environmental Protection Agency (EPA). The influence of the last three agencies is primarily felt through product review and approval, protection of intellectual property, and regulatory policies, respectively.

IMPACT ON INDUSTRIES AND OTHER APPLICATIONS

As discussed above, the biotechnology industry is very young and the vast majority of companies engaged exclusively in it have yet to commercialize any products. There are, however, a number of biotechnology products on the market or in use in a variety of applications. The diversity of these products and applications is

remarkable and will grow as researchers continue to explore new opportunities. In fact, observers estimate that, by the year 2010, biotechnology will influence in some manner industries that today account for $4.7 trillion, or 70%, of the U.S.'s gross domestic product. In this section of the report, we discuss biotechnology's impact on key industries and users both now and n the future.

Pharmaceutical. Traditionally, pharmaceutical researchers have developed new drugs by screening thousands of chemical compounds, some natural and some synthetic, for their apparent benefits in treating various diseases and other ailments. This screening is random, time consuming and, until recently, was done with little understanding of how the compounds worked in terms of the underlying biology, biochemistry, and pharmacology. Advances in biotechnology and related sciences over the last 20 to 30 years have revolutionized the industry by providing new methods for developing and producing drugs. At present, these methods are used to augment traditional screening methods.

Researchers are now using knowledge of cellular mechanisms and controls to understand the physiological basis of disease. They have clearly identified the role that hormones, enzymes, cell replication and other molecular-level processes have on the initiation and prevention of diseases. This is permitting researchers to design drugs that are aimed at specific interactions in the disease process.

Drug manufacturers are using recombinant DNA techniques, that is, techniques in which human genes responsible for production of specific enzymes or hormones are incorporated into the genome of microbial organisms. They then use carefully controlled fermentation processes to mass produce human proteins that until recently were not available in large enough quantities to be useful as therapeutic drugs. Between 20 and 30 such biotechnology-based drugs are currently on the market and over a 100 more are in development. Many of the drugs in development are intended to treat cancer or cancer-related conditions.6 At least one observer we spoke with predicted that within 10 years almost all therapeutic drugs will be developed by biotechnological means.

Medicine. The effects of biotechnology on medicine are already dramatic, and will certainly become more dramatic in the future. Traditionally, medical scientists have worked on diseases from the effects, the symptoms, backwards to the cause. Causes internal to the body were not fully understood. Scientists could describe in minute detail what was happening as it happened, but they could not explain, for example, why some people have a much higher risk of arteriosclerosis than others who have the same lifestyle. Biotechnology is changing this approach to medicine.

During the 1980s, scientists learned that it is feasible to understand the entire structure of human DNA, how the genes within the DNA work, where variations of the gene pattern are normal within humans, and where variations cause problems.

Scientists also learned how to modify the DNA in genes. With this knowledge, medicine may evolve to include diagnosing and treating many genetic diseases and disorders before they exhibit debilitating symptoms.

Thus far, scientists have built a very rudimentary map of DNA and are beginning to understand how some genetically simple diseases work. For example, at NIH, doctors have identified the defect in a single gene that causes severe combined immunodeficiency disease (affecting the "Bubble Boy") and are now able to fix the defect. While this disease and others like it affect only small numbers of people, they provide primers for researchers studying gene therapy. Researchers have also identified the genetic characteristics that cause cystic fibrosis and the gene that predisposes some women to develop breast cancer.

The supporting technical disciplines of biochemistry, engineering, and informatics are combining to accelerate the pace at which medical researchers understand and treat genetic defects in a commercially viable way. Although it may take generations of research before doctors have a full understanding of how the human body works and how to fix malfunctions, there is no question that biotechnology will revolutionize medicine as we know it.

Agriculture. The agriculture industry was a forerunner of modern biotechnology. Brewers initially applied basic principles of biotechnology (in the broad sense) in the production of ales and beer when they used yeast fermentation methodologies. Additionally, as early as 1865, Gregory Mendel studied genetic traits resulting from cross breeding peas. These initial steps served as a stimulus for scientists and farmers to develop new products, better crops in greater quantities, and stronger livestock that provide better meat products.

Traditionally, farmers have achieved these goals through selective breeding of plants possessing desirable characteristics. Additionally, the development and use of pesticides and fertilizers has produced larger and better plant yields. Animals and their resultant products also were improved through breeding the "best of the lot" and developing methods to reduce the incidence of diseases in livestock. These methodologies, although effective, have limitations and some are potentially harmful to the environment.

Thus, modern biotechnology is logically the next step in improving agriculture. Scientists are applying it to plants used for food in a number of ways. First, they are applying it in the development of disease and pest resistant plants. This application promises to rid plants of viruses, fungi or insects that could significantly alter their growth. Second, scientists are applying biotechnology to genetically engineer herbicide-tolerant plants, enabling farmers to treat for weeds without killing primary crops. In another application, scientists are altering plants' biological clocks so that farmers can control when they go to seed.7 In still another application scientists are

developing environmentally tolerant plants to assist in protecting crops against cold or drought. This application may also enable farmers to grow crops in much smaller fields. In a final food application that has perhaps the most direct impact on consumer perceptions, researchers are developing genetically-engineered plants with altered growth, development, or nutritional characteristics. This application includes the "Flavr Savr" tomato which stays fresh far longer than ordinary tomatoes, and thus, does not require shipping while green.

Biotechnologists are also exploring non-food uses for genetically-engineered plants. One possibility is to use plants as sources of drugs or vaccines. Another is to develop environmentally safe chemical and industrial products from plants. Finally, plants may provide a means to produce basic polymers to replace petroleum-based products.8

Animal agriculture is another area where biotechnology is making improvements in quality and quantity. First, researchers are using the technology to alter normal growth and milk production patterns in animals. For example, researchers are genetically-engineering swine to reduce intra-muscular fat and cows to produce greater quantities of milk. Another area that offers potential is the alteration of normal reproduction patterns in animals. Scientists have successfully manipulated embryos to predetermine the sex of offspring. Through this technique, beef farmers can increase the male populations in their herds, and, thus, their potential earnings. A third area where biotechnology is improving animal agriculture is in the area of health. New vaccines and drugs are helping to prevent animal disease and cure animal illnesses. Finally, bio-engineering is producing transgenic animals. This method offers potential to develop new and stronger species of animals. More significantly, it may result in animals which aid in curing human illnesses by producing selected human proteins that individuals suffering from genetic diseases lack.

Environmental Protection and Remediation. Historically, the major methods used to clean up polluted sites in the U.S. have been either "storage" or "incineration." There are problems associated with both of these methods. Storage, which consists either of containerization or transfer of waste to a landfill, does not detoxify the waste product and leaves the potential for leakage. It also requires physical disruption of the polluted site. Incineration is expensive and does not always fully destroy or detoxify the hazardous materials, and, like storage, requires physical disruption of the polluted site.

Biotechnology provides a third alternative, bioremediation. Bioremediation is the "process of using natural, as well as recombinant, microorganisms [microbes] to break down toxic and hazardous substances."9 The microbes, as part of their metabolic processes, breakdown the contaminants into safe byproducts, which the microbes either consume or excrete into the environment. Bioremediation is now available for a number of specific applications and is being developed for others. It was used very

successfully, for example, as part of the effort to clean up after the Exxon Valdez oil spill. Bioremediation is relatively inexpensive and is often accomplished on site without removal of the contaminated material. Additionally, the end product of the process is generally the complete and permanent destruction of the waste. A major disadvantage of bioremediation is that it takes longer than the other alternatives. Additionally, waste sites are often contaminated by several different toxic agents, making it difficult to find a microbe or group of microbes that is effective in such an environment.

In addition to cleaning up existing waste sites, there is a need to reduce the pollution that mankind continues to generate. It is estimated that we pollute our environment with almost five billion pounds of potentially harmful chemicals each year.[10] Biotechnology, along with advanced manufacturing and other environmentally conscious industrial processes, will play a major role in reducing or eliminating such pollution in the future. Methods, including replacing existing polluting processes with biotechnology-based pollution reducing processes (e.g., pulp preparation and paper bleaching) or bioremediation, will be employed before pollutants leave the site where they are generated. Typically, the waste stream at this point contains only one or two contaminants making it easier to identify a microbe which can breakdown the contaminants involved.

As of October 1991, there were over 130 firms in the U.S. working in the bioremediation field.[11] Nevertheless the level of commercial activity in this area is small. The level of Federal Government-sponsored research is also small, amounting in 1993, for example, to only 2.1% of the total amount funded by the Government for biotechnology research. To increase the commercial viability of bioremediation, continued research is required to identify microorganisms that can function in a variety of site conditions, including sites with multiple contaminants, and to develop methods that can speed up the bioremediation process.

Sensors. For years men have used a variety of sensors to detect the presence of, or changes in, certain substances in their environment. The use of canaries in coal mines to detect poisonous gases is an example of an early biological sensor. In recent years, scientists have developed a wide variety of new biosensors. These biosensors contain an active sensing element of biological origin closely connected to a transducer. Molecules such as enzymes, antibodies, cell receptors, or nucleic acids are commonly used as the active sensing element. Changes in these molecules resulting from contacts with a targeted substance or stimulus, such as airborne anthrax bacillus, or with light, sound, or radioactivity, cause the transducer to emit a detectable signal.

Biosensors are currently most prevalent in medical uses although other applications are becoming increasingly significant. Medical applications include the monitoring of drug levels and measuring of stress indicators. The desirability of in vivo(within the body) measurements is giving impetus to the development of

miniaturized medical biosensors.

The food processing industry uses biosensors to monitor the glucose content in wine and fruit drinks; to measure biochemical parameters for peanuts, cereal grains, and food additives; and to determine the lactic acid concentration during milk processing. Additionally, by monitoring the amount of nucleotide degradation in fish tissue, the industry is using biosensors to determine the freshness of fish.

Two areas of growing importance for the use of biosensors are the measurement of contaminant concentrations in soil and water. Additionally, researchers are now developing biosensors using molecules from the human immune system to detect chemical and biological warfare agents and toxins with greater specificity, sensitivity, selectivity, and speed than existing detection systems.

Forensics. Although in use for less than 10 years, DNA testing is now widely used as a means of identification in criminal investigations and trials. Three-fourths of the 221 criminal laboratories in the U.S. state they are very involved in conducting DNA testing. The popularity of DNA testing in forensics is attributable to a number of factors experts can test any body tissue, very small quantities of tissue, or tissue that is very old.

The forensic application of DNA testing involves two components: molecular biology and population genetics. Molecular biology techniques allow analysts to examine DNA directly to identify gene sequences. Forensic analysts use population genetics to analyze the degree to which a tissue sample from a crime scene is likely to be from the same source as a tissue sample taken from a known source (e.g., an accused suspect or a victim). Databanks of DNA profiles are used either to collect population statistics, which leads to a more accurate estimate of the frequency that a particular DNA pattern occurs in a population, or to provide criminal investigative support.

Mining and Oil Extraction. As an alternative to traditional mining and chemical leaching methods, mining companies are using microbes as leaching agents to extract various minerals from rocks. The microbes do this as part of their normal metabolic processes. In 1989, for example, over 30% of the copper produced in the United States was mined using microbial leaching. Mining companies are also using microbial methods to mine uranium and gold.

Researchers and producers are exploring and, in some cases, employing a variety of microbial-based enhanced oil recovery methods to increase the productivity of U.S. oil wells. These methods involve injecting a solution of microbes and a nutrient into an oil reservoir. The microbes feed on the nutrient and metabolically produce products that act on the oil in a variety of ways. For example, the microbes may produce solvents which change the oil's viscosity or they may produce detergent-like

substances which help oil break free from cracks and pores in the reservoir. These microbial-based recovery methods are one of the few techniques that may prove cost effective for many of the nation's independent oil producers.

Industrial Enzymes. Various companies are using fermentation to produce industrial enzymes to use as catalysts in manufacturing other products. For example, the starch industry uses industrial enzymes to break down complex sugars into simple sugars. Manufacturers also use enzymes to make high-fructose corn syrup and cheese. Novo Nordisk, a Danish company, has developed an enzyme which breaks down cellulose, the molecular base of cotton. Clothing manufacturers are using this enzyme in manufacturing blue jeans to give them a "stone-washed" appearance.12

To increase enzyme production rates, researchers are transferring the gene responsible for a particular enzyme from organisms in which the gene naturally exists to microorganisms that can produce the enzyme in much greater quantities. Researchers are also modifying genes to enhance the characteristics of an enzyme. They are attempting, for example, "to develop enzymes that are more stable in harsh solvents, more heat resistant, or that react with different substrates."13

Military. Biotechnology has a number of current and potential military applications. Medical examiners assigned to the Armed Forces Institute of Pathology use forensic-type DNA testing to assist in the identification of badly burned or damaged bodies resulting from accidents or other catastrophes. They will apply the same techniques, as necessary, to identify combat casualties. Biotechnology will also contribute to the battle-field of the future by providing defenses against biological weapons. For example, vaccines will provide advance protection against the effects of some biological agents, biosensors will provide warning when biological agents are present, and antibodies stimulated by vaccines will negate the effects of biological agent soldiers come in contact with, inhale, or ingest. Researchers at the Army's Natick Labs are also using biotechnology to unlock the secret of spider web protein. This protein shows excellent promise as a source for an ultra-strong, lightweight, elastic material that can be used to make protective gear such as bullet-proof vests. Finally, biotechnologists are developing biodegradable packaging materials and eating utensils which will help reduce field trash.

Other. A number of industries in addition to those listed above are also employing biotechnology for various purposes or conducting research involving biotechnology. For example, researchers in the paper industry are exploring use of microbial-based enzymes to reduce the amount of bleaching agents required in paper production. Biotechnology researchers are also active in the plastics industry. An application that researchers are only beginning to explore is the use of biological substances to make computer chips. Researchers believe these "biochips" may eventually be the key to further miniaturization of electronics.

ISSUES AFFECTING THE GROWTH OF BIOTECHNOLOGY IN THE U.S.

The promise that biotechnology holds for our economy and, ultimately, for the well-being of the American people, depends to a significant extent on the ability of the U.S. biotechnology industry to continue to mature in an orderly and timely way. In our view, the environment necessary for this to happen should include: (i) A vigorous basic research program; (ii) A reasonable supply of capital, particularly for companies whose products are still in development; (iii) An effective process for transfer of research and development results between academic and Government labs and commercial entities; (iv) An effective and efficient process for regulatory review and approval of biotechnology products; (v) A public that is knowledgeable about biotechnology and the risks associated with it; and (vi) An effective and efficient process for all elements of industry, the public, and Government to address and resolve ethical issues associated with biotechnological activities.

In this section of the report, we address potential obstacles standing in the way of the biotechnology industry's successful growth to maturity.

Funding. As discussed above, perhaps the most significant issue facing many of the U.S.'s dedicated biotechnology companies is the availability of funding. Recently, these companies have had more difficulty obtaining operating or start-up funding than in previous years. Some companies are facing bankruptcy if they are unable to find creative ways to fund themselves.

Funding for biotechnology in the U.S. comes from two major sources: the U.S. Government and private sources. Government funding is focused on basic research, and it funds more than half of the nation's basic research in biotechnology. Because of this focus, Government funding is not generally available to fund product development. Instead, product development is funded by private sources. Historically, venture capitalists have provided most of the funding for these companies during their first few years of existence. In some cases, the venture capitalists have continued to provide funding beyond this initial period. In a number of other cases, however, companies have gone public (sold stock) and the venture capitalists have used the initial public offering as an opportunity to recoup some or all of their investment.

During the 1980s and early l990s, venture capitalists and investors who bought shares in dedicated biotechnology companies had very high expectations regarding the promise of biotechnology. As evidenced by the number of companies that still do not have a product on the market, however, much of that promise has not yet materialized. As a result, investor enthusiasm for biotechnology has waned and dedicated biotechnology companies are finding it more difficult to obtain either venture capital or funds through public offerings. In 1994, venture capitalists elected to fund

existing rather than start-up companies and, consequently, only about 7 new dedicated biotechnology companies were started as compared to an average of about 50 new companies per year previously.14

To survive in the face of tighter funding, dedicated biotechnology companies are pursuing various alternative funding strategies. These include mergers between themselves and large pharmaceutical companies and various other forms of strategic alliances with the large pharmaceutical. These other alliances leave the dedicated biotechnology companies, at least in the legal sense, independent entities. Under the terms of these alliances, the large pharmaceutical company usually gets entitlement to first or exclusive use of products developed by the biotechnology company in exchange for a cash infusion.

At least one industry observer we spoke with projects that over the next five years the market value of dedicated biotechnology companies will triple from about $41 billion to more than $120 billion as the FDA approves numerous drugs for use. Nevertheless, this same observer projects that the number of dedicated biotechnology companies will decrease from about 1,300 to 1,000 during this same five-year period. Of the companies that disappear, some will be bought out or merged with other companies and others will simply fail primarily due to a lack of funding.

Food and Drug Administration (FDA) Approval Process. The amount of time it takes for the FDA to approve biologics (biotechnology derived drugs) is a key contributor to the financial problems faced by U.S. biotechnology companies. Without this approval, these companies are unable to market their products.

The mission of the FDA is to protect and promote the public health by providing standards for food processing and by assuring the safety and effectiveness of drugs and medical devices. Biologics must go through the same lengthy, rigorous process as chemically derived pharmaceutical. The average time from initiation of clinical trials to actual FDA approval of a new drug is between 10 and 12 years. The current FDA approval process is illustrated below.15

Preclinical testing (1-2 years)
Laboratory and animal testing for safety and biological efficacy.

Investigational New Drug (IND) application
Sponsoring company provides information on the new drug's composition, preclinical testing, and human clinical trial strategy. If the FDA does not reach a decision in 30 days, the sponsoring company may begin human trials.

Human clinical testing (up to 6 or more years)
Validate findings and identify any adverse reactions.

New Drug Application (NDA) (2-3 year FDA review)
The NDA summarizes data on all testing, the drug's chemical structure, manufacturing process, and labeling. NDA approval is the "green light" to commercially market the drug.

Biotechnology companies are concerned about both the lengthy approval process and the growing cost of developing a new drug. According to industry experts, the average cost of developing a new drug was approximately $70 million in the 1970s and is now approximately three to five times as expensive.

Most small biotechnology firms do not have the financial strength to remain in business without a sure promise of a return to their investors. Many investigational drugs fail late in the approval process. Increasing the efficiency of the approval process will stimulate economic growth, and help mitigate the biotechnology companies' financial risk.

The Biotechnology Industry Organization (BIO) has identified the following problems which FDA reform should address 16:

* Delay in moving drugs from discovery to approval
* Excessive regulation
* Lack of agency focus
* Failure to effectively use outside resources
* Impediments to international competitiveness
* Limitations on the dissemination of information

Over the last two years, the FDA initiated a number of policy and procedural reforms in support of the National Performance Review. The intent was to accelerate the drug and medical device regulatory review while still preserving critical health and safety standards. "Quick fix" legislative initiatives were also submitted to Congress. More complex issues, such as unapproved drug export restrictions, will require a longer term approach to properly redress.

FDA reform that directly impacts biotechnology includes several new "pre-approval" mechanisms to give seriously ill or dying patients access to new therapies before those therapies are approved for the market. These mechanisms include:

* "Treatment IND" application - Patients may receive unapproved therapies through medical
channels after the sponsoring company files this application following successful preclinical trials.
* HIV-infected patients unable to participate in formal human clinical trials may be given experimental treatments.
* "Accelerated or conditional approval" - drug test data is subjected to an FDA

analytical process that predicts clinical trial results. If favorable, the sponsoring company may market it. FDA approval is revoked if human clinical trials do not validate the prediction.

Congress, the pharmaceutical industry, and FDA joined forces in pushing the Prescription Drug User Fee Act (1992). This law provided the FDA with additional personnel to speed up drug and biologic reviews. The median time for approval of NDAs improved from 26.7 months to 19 months.

Drug companies are required to submit a manufacturing supplement to their original approval application for even minor changes to the content, or the manufacturing process, of a drug or biologic. This requirement adds months to the approval process and increases the FDA's backlog of documents to review. Under an FDA proposed policy, new flexible guidelines will establish what types of manufacturing changes need FDA approval. Everything else will only require a 30 day notice to the FDA.

Another major drug industry complaint is the prohibition against exporting unapproved drugs to other countries. Many companies believe that if another country approves the drug, U.S law should not impede export. This would provide sponsoring companies with funding while the FDA approval process continues. The FDA has agreed to discuss with Congress some potential changes to the Federal Food, Drug, and Cosmetic Act that might provide some relief in this area.

Academia, industry, and the FDA are revisiting clinical trial methodology for faster, more efficient means of arriving at a safe, responsible approval process decision. This will lead to fundamental changes in the current clinical trial process.

The FDA is determined to maintain its independence during its reform efforts, and ensure that the best of its current policies are maintained. The agency believes this is essential in order to maintain public trust and confidence in the agency's decisions.

Patents and Technology Transfer. Scientists are advancing the molecular biology, DNA, and human genome knowledge base at an extraordinary pace. Many scientists and business entrepreneurs are also exploring and identifying ways to commercialize these new discoveries. These two efforts, although related, create divergent needs and concerns regarding patent and technology transfer issues.

Rapid dispersion of research results increases the productivity of everyone performing related research in at least two ways:

* Scientists can either build onto the knowledge or pursue offshoots for further investigation.

* Scientists can avoid duplication of effort.

On the other hand, companies seeking to exploit research commercially are motivated to avoid sharing research results to maintain the commercial viability of their projects.

Patents. A key element in efforts to close the gap between these divergent interests is the U.S. patent process. This process serves two major purposes:

* Individuals and companies are encouraged to disclose their inventions in order to increase society's knowledge base.
* Individuals and companies have an incentive for incurring the risks and costs necessary to develop innovative products and processes.

Without an effective patent system, biotechnology companies would find it difficult, if not impossible, to survive. They could not justify assuming the high risk and cost inherent with new product development, nor could they attract investors.

The U.S. patent system is one of the most generous in the world with respect to what is patentable. Unlike many other countries, the U.S. grants patents for genetically-engineered plants, animals, and microorganisms. Despite this advantage, many U.S. firms have concerns about the U.S. patent system. They believe it is much too difficult and time consuming.

Over the last several years, the Patent and Trademark Office (PTO) has generally rejected a higher percentage of biotechnology patent applications (70%), and taken much longer in granting biotechnology Patents than patents for other inventions.17

Besides increased legal and administrative expenses, there are at least three negative consequences resulting from delays in granting biotechnology patents:

* Decreases the ability to obtain funding
* Affects the decision to file in foreign countries
* Increases the likelihood of duplicative research

In 1988, the PTO initiated reforms to improve the review process for biotechnology patent applications. Although some changes were implemented, biotechnology patent review cycles were not significantly shortened. The PTO recently published guidelines for the amount of supporting data that examiners can require applicants to submit. What, if any, effect this will have on processing times is not yet clear.18

Some biotechnology companies are also concerned about the effective period of their patents. U.S. patents are valid for 17 years, with an available 5-year extension for a human drug product or a medical device subject to FDA review. Even with an extension, an FDA approval cycle of 10 to 12 years can reduce the term during which a patent protects a marketable product. Under the General Agreement on Trade and Tariffs (GATT) Treaty, the patent term will increase from 17 to 20 years effective in June 1995. Although not significantly longer, this increase will provide limited relief to concerned biotechnology companies and will align the U.S. patent protection period with that of most other countries.19 These timelines are illustrated at the end of this section. The graph shows the general nature of the overlap between the FDA approval process and the patent approval
process.

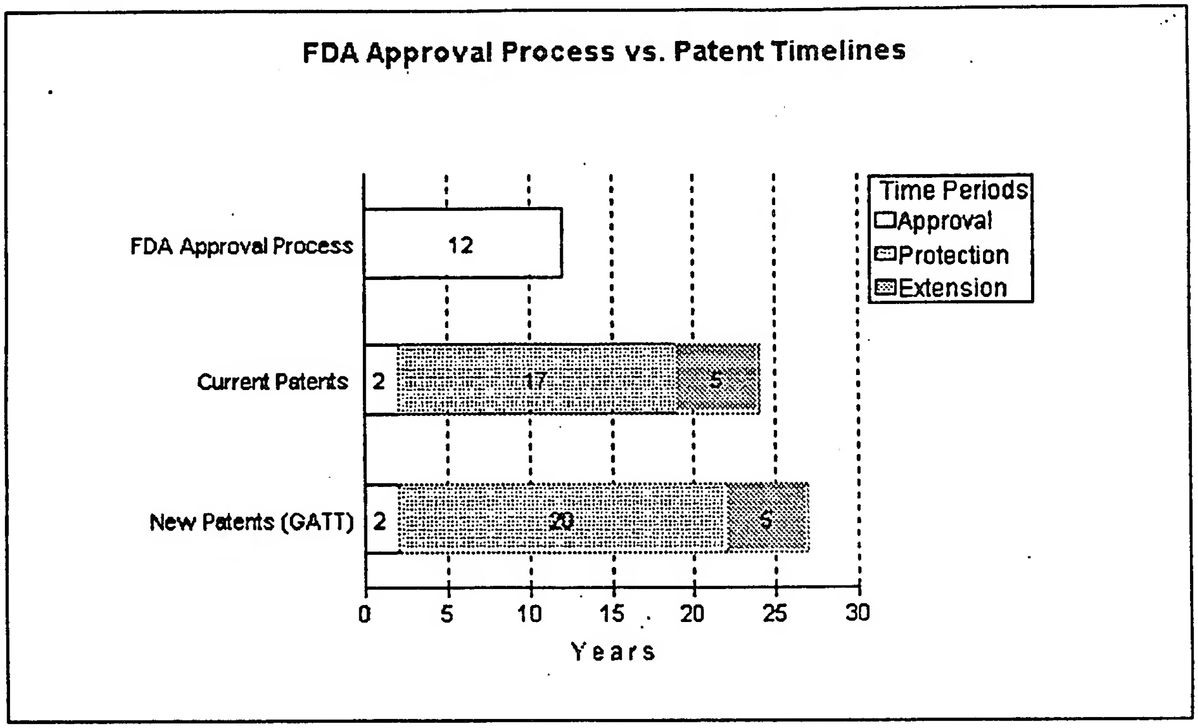
Technology Transfer. The U.S. Government sponsors over half the domestic basic research in biotechnology. Therefore, it has a vested interest in ensuring that the research results are used in ways that maximize national benefits. The NIH and other agencies actively encourage sharing of research results and have established various data bases that allow researchers to rapidly access the latest information.

Congress has passed two technology transfer laws to encourage cooperation between laboratories and commercial users:

* **The Bayh-Dole Act of 1980** provides uniform policy guidance on the transfer of technology and ownership of inventions developed using federal funding. The Act grants small businesses, non-profit organizations, and universities the right to retain ownership in patents and to license other entities to use their inventions.

* **The Federal Technology Transfer Act of 1986** provides incentives for federal laboratories to enter into cooperative research and development agreements (Crates) with industry, and allows federal employees whose work results in patented inventions to share royalties received under licenses with industry.

So far, universities and government laboratories, where the bulk of Government-sponsored research is conducted, have not aggressively taken advantage of these laws. However, as Government R&D funding becomes tighter, more of these activities are starting to actively pursue technology transfer opportunities.



Safety and Public Perceptions. A number of individuals and groups have raised questions about whether some aspects of biotechnology are really safe. Most of these questions focus on issues concerning the toxic effects that genetic manipulation might have on humans and other organisms, allergic effects that might result from genetically altered material, and the effect that genetic-ally altered material might have on the environment. Individuals and companies engaged in biotechnology, as well as government regulators, appear to recognize that these are legitimate questions that need to be resolved before biotechnology products are approved for use or are introduced into the environment.

In assessing the risks of any given biotechnology project, the scientific consensus is that "the risks associated with genetically engineered organisms are similar to those associated with nonengineered organisms or organisms genetically modified by traditional methods, and that these risks may be assessed in the same way." 20 Government regulatory agencies, therefore, have reviewed biotechnology products using the same standards and procedures as they have for other products. Many companies have argued that this use of existing procedures is too slow and fails to recognize differences inherent in biotechnology. Knowledgeable experts generally agree, however, that from a purely safety perspective, the regulatory process is effective in protecting the public and the environment from any potentially adverse effects.

A key to the commercial success of biotechnology products is whether or not the public believes the products are safe. To date, there has been little public debate regarding the safety of pharmaceutical or medical diagnostic products that companies have developed or produced using biotechnological techniques. Observers attribute this to a lack of public awareness or a general willingness to accept products that are designed to aid in the treatment of diseases and to save lives. It is with respect to agricultural products that various groups and individuals have expressed the most concern. In some cases, these groups and individuals are relatively successful in creating widespread doubt about the safety of a biotechnology product. A good example is milk from cows that were given the bovine growth hormone, bovine somatotropin (BAST), to increase milk production. In the future, biotechnology companies, particularly those developing agricultural products, must recognize their products will be subject to campaigns questioning product safety. These companies need to be prepared to engage in meaningful discussions with citizen groups and the media to set the record straight. Perhaps more importantly, they need to get the general public involved in their plans for their products as early as possible.

Ethical Considerations. Manipulating life through genetic-engineering introduces significant moral, legal, social, and religious issues. The field of bioethics--"the systematic study of value questions arising in medical and life sciences fields" 21--has evolved from our attempts to identify, deliberate, and seek resolution of these ethical concerns. Bioethics includes health care ethics, biomedical behavioral research ethics, and the resultant development of public policy guidelines. Adding to the dilemma is the dynamic nature of biotechnology and the drive by firms to commercialize advances at the earliest opportunity. The research advances are proceeding at a rate that exceeds efforts to properly understand and frame the issues.

The following are some of the activities which may generate bioethical concerns:

* **Genetic screening and testing** to predict a person's predisposition to specific illnesses or sensitivity to a given substance.
* **Therapeutic applications of genetic research** including genetic-engineering and therapy, use of transgenic animals and plants, gene amplification, and fetal research. Significant concern centers around the fear of misapplying genetic research to promote eugenics and germ-line experimentation.
* **Population genetics and miscellaneous issues** covering protection of intellectual property rights, regulating access to genetic databanks, biological warfare, protection of the environment, safety, security, and free and informed consent.

In their book *Genetics*, Seasick and Knudtson propose 10 moral guidelines, or "working solutions", for genetic responsibility based upon currently known biotechnology applications. Some examples of these "genethic principles" include:

* An understanding of the nature of genes is essential to grasping the difficult moral issues involved.
* Since most human hereditary differences involve the interplay of many genes, it is dangerous to derive a causal relationship between human behavior and DNA "defects."
* Genetic information should aid personal decisions, not impose them.
* Germ-cell therapy, without the consent of all members of society, ought to be explicitly forbidden.
* The development of biological weapons is a misapplication of genetics that is morally unacceptable 22.

Bioethical issues strike the core of our very existence. Government, industry, academia, and the public must engage in essential debates of biotechnology policy and application. Some domestic and international biotechnology groups have taken on this task by stirring public interest, providing information to educate the public, and fostering much needed discussion. The quest for meaningful ethical guidelines will continue to evolve in relation to new genetic discoveries and new ways of applying current genetics.

In the U.S., the National Institutes of Health exercise some control over biotechnology applied to medicine through their funding of specific research projects. The Agricultural Research Service plays the same role for animal and plant research. Both of these agencies have representatives in various bioethics organizations. However, in the U.S., the level of public awareness and participation in bioethics forums appears minimal.

<u>A Sample of Significant Bioethical Questions</u>

Should we test for diseases or conditions for which there is no cure or therapy?

Will insurance companies and other organizations have access to DNA data, and, if so, which data?

Should industry determine the direction of genetic research based upon forecasted profit or revenue?

Should we establish boundaries for research which uses gene-splicing and recombinant techniques until we more fully understand the implications?

STRATEGIC VALUE

All nations that are actively involved with biotechnology have an interest in the

timing and location of its expansion as an industry sector. As its worldwide influence grows, biotechnology will play an ever increasing role in the development of national grand strategies and international relations. In this section of the report, we discuss why biotechnology has strategic importance to the U.S. and briefly assess the U.S.'s competitive position with respect to biotechnology as compared to the rest of the world.

Biotechnology and U.S. Grand Strategy. Biotechnology's strategic value to the U.S. lies mostly in its tremendous potential. As previously stated, observers have estimated that by the year 2010 biotechnology will play a role in industries that account for 70% or more of the nation's gross domestic product (GDP). This role will include providing more efficient and environmentally friendly manufacturing processes which will make industries using biotechnology more internationally competitive. Biotechnology will also provide employment opportunities for many highly educated individuals in a number of disciplines. In addition, biotechnology may play a role in the development of future generations of integrated circuitry. If so, the effects will ripple throughout the global marketplace. The potential impact of biotechnology on the U.S. economy, therefore, is very great.

Additionally, and equally important, the products and services that biotechnology may produce will, themselves, have significant strategic value. For example, U.S. developed genetically-engineered plant and animal strains that greatly increase the agricultural productivity of developing nations will allow the nation to establish supportive and mutually beneficial relationships with many countries and peoples. Development and marketing of bioremediation techniques and non-polluting industrial processes will allow the U.S. to stimulate business growth domestically and abroad while also demonstrating a leadership role in resolving worldwide environmental concerns. Health care breakthroughs offer the same economic and political benefits on an enormous scale.

In view of its strategic value, the nation needs to consider the future of biotechnology and its potential in the national and global economy. Its strategic value as an element of national power would be enhanced if strategic planning concerning it were integrated with other national strategies. The industry is currently poised on the brink of major growth. Although only a limited number of products from dedicated biotechnology companies are on the market, and there are less than 10 "break-away" companies with significant sales, many more products are in the approval cycle and an order of magnitude more are ready to be submitted for approval.

International Competition. The U.S. is the recognized world leader in the dynamic arena of biotechnology. To ensure sustained economic growth, biotechnology-based innovation and commercialization are essential. The tremendous economic potential and ever increasing worldwide use of biotechnology in other more

traditional industries serve to leverage the "industrial" influence it wields. Several actions will determine whether the U.S. maintains and effectively exploits its comparative advantage:

* Continuing support of basic research and innovation
* Focusing applied research on marketable targets
* Sharing of non-proprietary research results
* Restructuring industry for effective resource management
* Establishing international strategic alliances supporting technology transfer and market penetration
* Commercializing innovations regardless of origin
* Raising public awareness
* Partnering by qovernment at all levels

The foreign biotechnology community looks with envy at the resources available in the U.S. and the seemingly inexhaustible supply of new ideas and applications. However, it is clear that biotechnology breakthroughs are occurring in many other countries.

The European Union (EU) is placing strong emphasis on collaborative research programs through its Science, Technology, and Research and Development Commission. Research proposals submitted to the Commission for approval and funding must include a detailed justification and identify the other EU countries that will collaborate in the research effort. Significant drawbacks to this system include:

* Historical and cultural barriers between countries
* Time it takes to put a proposal through the process
* Requirement to recruit research partners from other countries

However, when a proposal is approved, the funding is provided and the research results are generally made available to all EU partners. Some, but not all EU countries are actively pursuing this growing funding source.

In our sampling of European countries, the Netherlands showed the most significant vertical integration with academia, industry, and government participating together to find biotechnological solutions to specific needs. Primarily an agricultural country, 70% of Dutch biotechnology investment is targeting agri-food industries, with significant government funding (33%) for programs that support the pharmaceutical/ biotechnology related infrastructure. The Netherlands also demonstrated the most active pursuit of EU funding for biotechnology research.

Other countries we visited do not appear to have a well integrated biotechnology sector. Although the government typically funds academia, an established working relationship between academia, government, and industry was not

evident or, at best, was in an early stage of development. We saw some movement toward an integration of academia and industry in the development of "technology parks" supporting small business ventures as spinoffs of academic research.

Although we did not visit Japan, we understand that it has targeted biotechnology as a strategic industry of the future, but has not yet developed a significant biotechnology capability.

On the whole, we believe foreign biotechnology capabilities will not be competitive with U.S. capabilities for the foreseeable future. However, while U.S. capabilities are broad based and comparatively better balanced between basic and applied research, European research and product development emphasizes niche markets. These include, for example, agri-cultural products throughout the Netherlands, hormones and enzymes at Denmark's Novo Nordisk and Belgium's Solvay, and fermentation bacteria at Denmark's Christian Hansen.

These multinational companies all have large, aggressive overseas operations and approach biotechnology from a business perspective. They are pursuing biotechnology because it allows innovation within their core competencies and supports their corporate strategic plans. They emphasize an international awareness of their customers and develop very competitive marketing strategies for their biotechnology products. In these niche markets, foreign companies represent strong competition to U.S. products.

The world-wide availability of financing, telecommunica-tions, production technologies, labor, transportation, and sophisticated business development practices make it easy for companies to transfer technology or move production between countries. Once the benefits of biotechnology are more widely recognized, the market demand will provide great incentive for further investment in biotechnology development and commercialization. This availability of funding, coupled with a research segment that remains cash hungry and pressured by investors, may lead biotechnology firms to take the path of least resistance in the global market to maximize profits. Thus, companies may elect to pursue opportunities to transfer technology or relocate operations overseas. Consequently, the U.S.'s strong lead in biotechnology could evaporate quickly, at least insofar as significant commercialization efforts go, if the business environment within the country is not competitive with that in other countries.

GOVERNMENT ROLE: CREATING A SUITABLE ENVIRONMENT FOR GROWTH

Considering the enormous potential of biotechnology, the Government should recognize that it has a role to play in enabling continued development of the industry. Awareness of biotechnology sector characteristics is essential if the Government decides to help create an environment that minimizes obstacles to advancement and

incentivizes domestic growth. In this section of the report, we discuss what role the Federal Government, and, in some cases, state governments should play in supporting the development of the biotechnology industry.

Strategic Planning. The Government should develop an overall strategic industrial policy based on a long term vision that emphasizes basic and applied research and aggressive commercialization. To a degree, the FDA and the Patent and Trademark Office recognize the need to enable biotechnology-based efforts and are putting programs and personnel in place to support it. However, if the Government does not recognize the industry as a potential major player in the world economy, biotechnology will not factor in such decisions as fiscal and monetary policy, business incentive programs, health care reform, technology development programs (i.e., NSF, DoA, DoD, NIH, DoL, DoC), and education.

Financial Support for Basic Research. Basic research, which represents a large portion of the current industry structure, has always depended on investment by the Government. Continued support through the NSF, NIH, and other basic research organizations, including dual use of government laboratories as applicable, will foster continued growth in the underlying scientific knowledge base that is supporting industry development and growth. The Government should also continue funding for selective applied research projects such as those at the Army's Natick Labs.

Policies that Encourage Investment in Applied Research and Development. A survey of dedicated biotechnology company executives reports that the biggest obstacle to more rapid advance of biotechnology is funding. As previously discussed, the early promise of biotechnology has not yet resulted in an abundance of profitable products. Therefore, considering the cost and time involved in crossing the "death valley" of product development, many small biotechnology companies are having difficulty getting enough capital to complete development efforts. Companies are turning to sales, mergers, and virtual integration to carry them through. To incentivize commercial development, the Government should review its fiscal and monetary policies and other policies that may impact on R&D investment decisions. Granting tax incentives for R&D investment or adjustments to capital gains for investors in biotechnology, for example, would improve the domestic business environment for biotechnology companies.

Streamlined Regulatory Processes. Because all U.S. companies must live in the legal and regulatory environment as established by government policy and law, particular attention should be focused on the government players in this arena. For example, continued streamlining of the FDA approval process would address significant industry frustration and speed the commercialization of new products. Adjusting the patent process to support unique aspects of biotechnology development would help resolve industry concerns with the patent process. Appropriate EPA regulations coupled with fiscal policies could stimulate the use of environmental

friendly biotechnology. Concentrated efforts to anticipate ethical and moral issues regarding patenting of biotechnology products and processes to establish proper and acceptable precedents will be a challenging, but necessary hurdle.

Public Forums. An essential element of support for biotechnology will be increased public awareness and education. The negative publicity or misinformation generated by books such as "The Hot Zone" and movies such as "Outbreak," and the issues of privacy and ethics surrounding DNA fingerprinting and patenting of living organisms frequently seems to outweigh favorable impressions of biotechnology in the minds of the general public. A properly informed public presumably will increase the marketability of biotechnology products; a misinformed one may shrink the market considerably.

At this early stage of industry development, both the Federal Government and state governments can have positive, synergistic impact by providing forums for public awareness and discussion. These forums need to openly discuss the scientific, ethical, moral, and privacy issues surrounding biotechnology. Biotechnology applications raise complex issues which are often without precedent. Governments, industry, and, in particular, academia must approach public awareness as a team.

RECOMNENDATIONS

In view of the above, the Government should:

* Recognize biotechnology as a potentially significant element of national power and develop a broad based coordinated policy to support industry development.
* Continue to provide funding for basic research, with selective funding for applied research.
* Provide fiscal and monetary policies that encourage and support applied research and development of biotechnology.
* Continue to streamline the processes, regulations, and laws affecting new product approvals and the path to commercialization, with particular emphasis on the FDA, PTO and EPA.
* Provide forums for public awareness of the potential of biotechnology and debate of the ethical issues related to biotechnology. Implement solutions in policies as appropriate.

CONCLUSION

Biotechnology has the potential to change our lives in many ways and will have widespread effects on many industries within the U.S. and around the world. The way the U.S. responds to this potential will profoundly affect the physical and ethical wellbeing of the American people and the competitiveness of the American economy. A conscientious nurturing

of this fascinating and vibrant industry is in the nation's best interest as it will likely revolutionize most traditional industries, address global social issues, and enhance our quality of life. Global stability is a primary strategic issue -- biotechnology will have great influence in any successful solution.

ENDNOTES

1. European Federation of Biotechnology, Task Group on Public Perceptions of Biotechnology, Briefing Paper 2, "Biotechnology in Foods and Drinks," January 1994, page 1.

2. The only exceptions, are a small number of virus in which the hereditary material is ribonucleic acid (RNA) rather than DNA.

3. As defined in U.S. Congress, Office of Technology Assessment, Biotechnology in a Global Economy, OTA-BA-494, Washington, DC: U.S. Government Printing Office, October 1991, "Recombinant DNA~ includes a broad range of techniques involving the manipulation of the genetic material in organisms. The term is often used synonymously with genetic engineering. "Cell fusion" is the joining of the membrane of two cells, thus creating a hybrid cell that contains the nuclear matter from the parent cells. "Bioprocessing" is processing that uses complete living cells or their components (e.g., enzymes, chloroplasts) to effect desired physical or chemical changes.

4. "Biotech 95: Reform, Restructure, Renewal", The Industry Annual Report, Ernst & Young LLP, 1994, page 54.

5. "Biotech 95: Reform, Restructure, Renewal", The Industry Annual Report, Ernst & Young LLP, 1994, page 54. The report noted that its calculation of survival times (its "survival index") was based on balance sheet data, which, in some cases, fails to recognize various "off-the-books" financial arrangements.

6. Ibid., page 76.

7. Weiss, Rick, "Researchers Discover Plants' Biological Clock," Washington Post , February 24, 1995.

8. World Future Society, "Foodless Farming," The Futurist, MayJune 1994, pages 55-56.

9. Biotechnology Industry Organization, "Treating Hazardous Waste Through Biotechnology," Backgrounder Series, Sept. 1991, pages 1-3.

10. Biotechnology Industry Organization, "Protecting Our Environment," Biotechnology at Work, 1992, pages 1-6.

11. U.S. Congress, Office of Technology Assessment, Biotechnology in a Global Economy, OTA-BA-494, Washington, DC: U.S. Government Printing Office, October 1991, page 12.

12. Based on representations by a company employee during a meeting on 4 May 1995.

13. U.S. Congress, Office of Technology Assessment, Biotechnology in a Global Economy, OTA-BA-494, Washington, DC: U.S. Government Printing Office, October 1991, page 121.

14. Information provided by an industry analyst during discussions with our group in February 1995.

15. V.S. Congress, Office of Technology Assessment, "Biotechnology in a Global Economy", OTA-BA-494 (Washington DC: V.S. Government Printing Office. October 1991), page 76.

16. Biotechnology Industry Organization, "FDA Regulatory Reform", Concept Paper February 27, 1995, pp. 1-6.

17. Statement made by representative of the Patent and Trademark Office during discussions on 3 February 1995.

18. Statement made by representative of the Patent and Trademark Office during discussions on 3 February 1995.

19. Information regarding the extension in the term of V.S. patents provided by representative from the office of the Director of Technology Transfer & Development, Human Genome Sciences, Inc., Rockville, MD, during discussions on 17 March 1995.

20. U.5. Congress, Office of Technology Assessment, Biotechnology in a Global Economy, OTA-BA-494 (Washington, DC: V.S. Government Printing Office, October 1991, page 175).

21. VanCamp, Ann J. "BIOETHICSLINE & Other Sources of Ethics Information," Database, 15, 4, August 1992, pages 102-105.

INDUSTRY STUDY

#6

CONSTRUCTION

TABLE OF CONTENTS

PARTICIPANTS

Students

Ms. Paula Bell, DMA

LTC Connie Carmody, USAF

LTC Allan Carroll, USA

COL Ronald Hawthorne, USA

LTC John Herd, USAF

COL John Masters, USAF

CDR Dave Morrison, USN

Mr. Bill McCullough, NSA

LTC Owen Powell, USA

CDR Brian Schires, USN

CDR Lars Wallis, USN

Ms. Kim Weirick, D/N

Faculty

Dr. Hugh Conway, Dept of Labor

COL Dick Unser, USAF

PLACES VISITED

Domestic

Naval Research Laboratory	Washington, DC
Association of General Contractors	Washington, DC
National Building Museum	Washington, DC
Port Authority of New York and New Jersey	New York City, NY
Parsons-Brinckerhoff, Inc.	New York City, NY
Boston Harbor Outfall Project	Boston, MA
Law Engineering and Environmental Services	Atlanta, GA
Georgia Tech University	Atlanta, GA
Chicago Sewer Project	Chicago, IL
Bechtel Group, Inc.	Washington, DC
American Institue of Architects	Washington, DC
National Association of Homebuilders	Washington, DC
Northridge	Bowie, MD
Naval Special Warfare Command	San Diego, CA
University of California at San Diego	La Jolla, CA
Fluor-Daniel Corporation	Irvine, CA
Holmes & Narver	Orange, CA
California Dept. of Transportation	Los Angeles, CA
Dames & Moore	Los Angeles, CA
The Parsons Corporation	Pasadena, CA
Ray Wilson Company	Pasadena, CA
Seven Oaks Dam Project	Highland, CA

International

Danish Council of Consulting Architects and Engineers	Copenhagen, DK
Danish Contractor's Association	Copenhagen, DK
Storebaelt Bridge and Tunnel Project	Korsor, DK
Orestadselkskabet (City of Future Project)	Copenhagen, DK
The National Institute of Occupational Health	Copenhagen, DK
Arbejdstilsynet (Danish Working Environment Service)	Copenhagen, DK
Royal Institute of Technology	Stockholm, SW
Swedish National Road Administration	Stockholm, SW
Skanska	Stockholm, SW
Arlandabannan Project	Stockholm, SW
Varby-bridge Site	Stockholm, SW
Stocksund-bridge Site	Stockholm, SW

Nordic Construction Company (NCC)	Stockholm, SW
Kjessler & Mannerstrale	Stockholm, SW
Swedish Council for Building Research	Stockholm, SW

GUEST SPEAKERS

Jeffrey L. Beard	Design Build Institute of America
Dr. Terry Ryan	George Mason University
Gerald Olenjniczak	National Training Fund, Sheet Metal and Air Conditioning Ind.
Vincent A. Panvini	Sheet Metal Workers' International

INTRODUCTION

Construction is the process of transforming materials and supplies into a finished built product. While the finished product can be produced in a plant and installed on site, such as prefabricated buildings and sheds, generally the finished product is fabricated at a site selected by the purchaser. The product is not standardized, but is designed on a custom basis. Generally the customer contracts with a construction firm to build a project for a fixed price.

The products of construction are houses, industrial and commercial facilities, and infrastructure such as roads and utilities. Construction quality affects the competitiveness of U.S. industry and the safety and quality of life of our people. The industry can be considered to be a process that includes planning, designing, manufacturing, site construction, and facilities management.

Demand for construction is substantially influenced by government policies and regulations, and demand for construction services results from public and private investment decisions. Construction is frequently referred to as the barometer of the national economy. It fluctuates along with the general health of the economy. Because the level of investments fluctuates strongly with the business cycle, demand for construction services fluctuates more than that of many other industries.

Knowledge of the construction industry is necessary to ensure there is a capability to surge or mobilize in time of war or other national emergencies. The Federal civil works program, administered by the U.S. Army Corps of Engineers, provides the United States a strategic reserve for mobilizing to meet national security needs. Action by Congress in establishing a dual capacity and responsibility for the Corps--nation building during periods of peace and defense construction in times of conflict--has ensured the capability for mobilizing the construction industry is there in time of national emergencies.

STRUCTURE

Construction in the United States is a large disaggregated industry. It includes architects, engineers, technical specialists, contractors, subcontractors, material suppliers, skilled craftsmen, other trades personnel, laborers, and equipment suppliers.

There are over 500,000 construction contractors in the U.S. Over 90 percent of these firms are very small with fewer than 10 employees; two-thirds have fewer than 5. There usually is a unique team (owner, architect, engineers, general contractor, specialty contractors, etc.) for each construction project. General contractors take responsibility for an entire project, but subcontract most of the actual construction.

Most construction firms operate in a particular locality or region, but some firms are national or even international in scope. The largest contractors represent less than 10 percent of all contractor firms but account for about 30 percent of all contractor receipts. A number of large engineering and contracting firms that are national or international in scope have annual receipts in the billions of dollars. These establishments are typically called upon to undertake massive construction projects such as dams, power plants, and skyscrapers. Leading firms include Bechtel Group Inc., Brown & Root Inc., Fluor Daniel Inc., and The Parsons Corp.

The conditions of entry to the construction industry are considered minimal. The advantages possessed by established firms are size, experience, and reputation.

The construction industry experiences an inordinate amount of business turnover. While establishing a firm is relatively simple and often requires little capitalization, the rate of business failure is high among small contractors. Although the total number of establishments has remained fairly stable over the years (about 500,000), the ratio of new and discontinued businesses to operating businesses is considerably greater in construction than in most other industries.

U.S. CONSTRUCTION OUTLOOK

Domestic construction involves new construction activities and maintenance and repair work.

In 1987, the Census of Construction found that about 66% of the construction industry's work was for new construction; 19% was for additions, alterations, and reconstruction; 10% was for maintenance and repair; and 5% was unspecified. In 1994, new construction accounted for about 58% of the industry's business; with additions, alterations, and reconstruction comprising 20%; and maintenance and repair totaling 22%.

In 1994, the value of new construction put in place was equal to about 7.5% of GNP. This is well below the post-World War II peak of 11.9% of GNP attained in 1966, and about the same as the cyclical low of 7.7% in 1982. There has been a downward slope since 1986 when construction was 9.6% of GNP. Construction's share of GNP is expected to remain the same for the next several years. However, this measure tends to understate the importance of construction in the economy because several types of construction activity not included in the new construction data have grown rapidly during the past decade. These include maintenance and repair, commercial/industrial renovation, and hazardous waste cleanup.

The number of housing starts amounted to 1.43 million units in 1994. Public works construction remained at the 1993 level, as record spending for highways was

offset by cuts in military construction and some conservation and development projects. Private nonresidential construction increased for the first time since 1990 led by increases in stores and service buildings, manufacturing facilities, telecommunications facilities, and office buildings.

Remodeling and repair work increased in 1994 reflecting heavy sales of used homes during 1993-94 and the growing stock of housing. Nonresidential building improvements (commercial remodeling and renovation) also reached record levels.

VALUE OF NEW CONSTRUCTION PUT IN PLACE 1989-1999

(in billions of 1987 dollars)

Type of Construction	1989 Actual	1994 Estimated	1999 Projected
Total	\$409.5	\$419.6	\$454.3
Residential	\$181.3	\$195.1	\$206.8
Single Family	107.8	125.6	125.6
Multi-family	20.6	10.9	13.3
Home Improvement	52.9	58.6	67.9
Private Nonresidential	\$137.3	\$115.0	\$128.2
Stores/Shopping Cen	31.5	26.0	28.7
Manufacturing Fac	18.9	17.5	21.3
Office Fac	29.3	13.6	14.3
Elect Utilities	11.8	11.5	14.0
Hospital & Instit	7.7	8.7	10.6
Telecommunications	8.5	8.6	10.0
Other	29.6	29.1	29.3
Public Works	\$ 90.9	\$109.5	\$119.4
Highways	26.8	36.6	40.4
Educational	16.0	18.8	19.8
Oth Public Bldg	14.1	15.8	18.3
Misc Pub Struct	7.6	9.6	11.1
Sewer Systems	8.2	8.9	9.8
Water Supply	3.5	5.2	6.0
Other	14.7	14.6	14.0

Demographics have a great influence on the construction industry. Population changes and the age distribution influence future trends in the industry. Domestic construction is critical in providing the basics of housing and infrastructure facilities. Infrastructure facilities not only provide quality of life, but are an important factor in U.S. productivity and international competitiveness.

The residential sector is by far the largest component of the construction industry. In terms of dollar value, 1994 residential housing construction and home additions constituted 46.5% of the value of new construction put in place. By 1999 it is projected that the residential sector will constitute 45.5% of the value of new construction put in place. The demand for new housing will be limited by demographic factors and by the slower buildup in homeowners' equity. Fast growing markets will be housing for the elderly and for those in the 18-25 age group. These groups will require smaller units with special design features that appeal to or may be needed by senior citizens and single people. Home improvements will become a larger portion of the residential market as people hold on to what they have.

Nonresidential construction is less interest rate sensitive than housing but more dependent on corporate profits. Changing global trade patterns especially NAFTA and GATT will have major effects on industrial construction. The modernization of the Pacific Rim economies may have a negative effect on nonresidential building.

Office construction is being revived and is expected to remain at 1994 levels or slightly less by 1999. Environmentally sensitive construction requires architects and engineers to design in de-construction so that buildings can routinely be dismantled and materials recycled. Commercial building demand is affected by business management practices such as downsizing, temporary work forces, and inventory control techniques. In addition, the location and type of commercial construction are increasingly influenced by technological developments that foster telecommunications, electronic shopping, home offices, teleconferencing, and globalization of information services.

The public works sector of construction in 1994 was 26.1% of the value of new construction. This sector is essential to maintain because of its importance to U.S. productivity and international competitiveness. Public works construction will increase modestly during the 1995-1999 period, assuming moderate economic growth and gradually declining interest rates. However, efforts to control and reduce the Federal budget deficit will limit government spending for public works projects despite the well-publicized need for additional infrastructure investment. Because utility companies can raise capital, energy and power projects should be a rapidly growing category within public construction.

After 1995, sewerage construction will continue to grow, but at a slower rate than the overall economy. Funding may shift from the Federal Government to state

and local levels. The Clean Water Act and the Water Resources Act will continue to ensure funding for waterworks projects. Because of the ability of water utilities to raise their own capital, waterworks will be one of the more rapidly growing categories of public construction. The aqueduct systems of most older cities are so ancient that extensive replacement of work must be done each year. For the United States as a whole, the current level of construction is much less than that needed to replace the waterworks every 50 years, which is the recommended practice.

Highway construction expenditures are projected to increase primarily to prevent further decline in the condition of the nation's highway infrastructure. Most highway construction is funded with gasoline taxes. The public may approve higher gas taxes if the receipts are used to improve highway infrastructure. Several states have awarded contracts to private construction joint ventures to build toll roads that compensate companies for their costs and allow for the eventual transfer of the project back to the municipality. This type funding may become more popular in the future. Mass transit construction will become larger in the future. A large share of discretionary Federal transportation grants is being diverted from highways to mass transit because of air pollution concerns and local development policies.

Education related construction is expected to grow for the next several years because demographics indicate that the supply of existing schools is inadequate to meet the need of an increasing number of students. For example, New York City's public school system is expected to add 21,000 new students to its system each year until 2001.

Conservation projects are expected to decline for the rest of the decade. This bodes ill for the Corps of Engineer's ability to maintain surge and mobilization capabilities in the event of war.

MARKET CONDITIONS AND GOVERNMENT INFLUENCE

Financing

Construction project financing consists of lines of credit and short- and long-term loans. In the U. S., short-term construction loans are provided by commercial banks. Long-term loans (mortgages) are provided by financial institutions such as insurance companies or pension and trust funds. Based on interviews with representatives of several firms doing non-residential construction, obtaining loans is not a major problem in the United States; but is a much bigger problem internationally.

Most world financing is for infrastructure projects in lesser developed countries. Under today's system, tax revenues and government borrowing are the dominant source of infrastructure finance. Borrowing--whether from official or private sources--

is backed by a government's full faith and credit, and thus by its tax powers.

International firms seek business in developing countries, often with local companies, on new infrastructure projects. These firms bring their management expertise and technical skills as well as their credit standing and ability to finance investments in developing countries. Major electric, telecommunications, and water utilities in industrial countries face slow growing demand in their home markets. As a result, they are vigorously seeking high-yield investments in developing countries. These investments will create opportunities for U.S. construction firms. Currently, U.S. construction conglomerates are active in toll-road construction and power projects in developing countries. However, in visits to firms participating in competition for projects in other parts of the world, their frustration was evident. The comment made by representatives of more than one firm was "you need to bring funding with you when you compete." In many cases the firms could not, on their own; provide enough financing and felt the United States Government could do more to provide funding to support obtaining contracts abroad.

Official Development Assistance (ODA) funds are provided by Japan as bilateral aid to assist lesser developed countries. Some $75 billion has been committed for multilateral and bilateral grants and loans through 1997 to aid developing nations in infrastructure and social development. U.S. firms are encouraged to compete for this funding by partnering with Japanese firms to conduct project feasibility studies.

Pricing

Construction projects vary in size from small buildings, which may take weeks to complete, to major public works projects such as highways and dams, which can take years to complete.

Today the size of construction projects has grown so much in scale and technological complexity that changes are being considered in the management of those projects. The construction industry is in the process of changing the packaging and delivery systems of projects. Approaches such as design-build, construction management, program management, multi-disciplinary teams, and partnering are evolving to better manage how to integrate both the financial and operational elements of construction.

The traditional design-bid-build process is the primary method for pricing buildings today. The process uses detailed plans and specifications as the basis for contractors to prepare their bids. Contracts are usually for a firm fixed amount. In the public arena, owners use competition to determine the lowest possible price. Under this process bidding errors can occur. Errors are usually those of omission that reduce the bid estimate. Award of contracts based on low bids that contain

errors can reduce the quality of construction or increase the total cost to correct the error. It may lead to conflict between contractor and owner. In such cases, the bid price may not be the final price the owner pays.

A contractor sets the price of a project through a bid or proposal preparation process. Automation through faxes and CAD systems have revolutionized the bid process with accurate, fast, and reliable pricing information. Typically a contractor must prepare this estimate in a four to eight week span, not much time considering the complexity of many of these contracts. The cost of preparing a bid ranges from $7,500 to $330,000 for projects ranging from $1,000,000 to $50,000,000. If the contractor does not get the job, the funds spent preparing the estimate are paid for out of existing or future projects.

To arrive at a price, or a bid offer, the contractor goes though a process of estimating direct costs and indirect costs that include general overhead and profit mark ups. A number of factors are important to pricing such as market conditions, construction duration, complexity and technical risk, and the cost of financing.

Direct costs include materials, labor, equipment rental and depreciation, bid preparation, performance bonds, and subcontracts. Subcontractors use the same process in providing their bid to a general contractor or higher level subcontractor. The experience of the estimator is crucial. Complex plans and specifications complicate seemingly straightforward material takeoffs. Volume discounts can be significant in reducing the cost of construction material. Manpower estimates are more complex as various crafts and experience must be translated into productivity estimates. An impact noted by firms visited was that labor costs are influenced greatly by contributions to workman's compensation.

The breadth and depth of contractor experience is important in setting prices. Experience with a particular type project or customer enables the contractor to be familiar with problems and ambiguities in plans and specifications. Contractors experienced in particular submarkets enjoy a cost advantage over those that lack experience.

Construction takes place over time. Both the physical characteristics of the project and the actual cost will differ from both the original plans and specifications and estimated project cost. Material and labor costs can change quickly and dramatically because of fluctuations in supply or demand. For instance, lumber prices rose following the increased demand caused by Hurricane Andrew. Similarly, demand for craftsmen may exceed supply in a local market forcing contractors to pay higher wages to attract the needed labor supply. This is the case with brick masons working on Olympic facilities in Atlanta and several multi-billion dollar public works projects in Boston. Projects in the surrounding areas must also pay the increased labor cost. If such a change occurs before the contract, bid prices increase. If the

change occurs during a contract, the contractor will lose profit if the contingency for unknown situations is not large enough.

Contractors take these uncertainties into account by anticipating cost escalations in their estimates. Other elements of uncertainty include unfavorable weather, community protests, litigation, and poor subcontractor or supplier performance. Contractors vary in their ability to reduce these uncertainties which produces significant variations in cost estimates. Representatives of firms visited mentioned that the current process of bidding by specific line item hampers work-in-progress by having to renegotiate during the construction period. One firm prefers a concept of mutual cooperation in their construction projects where the owner and the contractor agree on a basic price and work together during the construction period to produce the end product. They believe this is a more productive method, involving everyone and reducing costs from litigation and constraints imposed in advance.

Competitive contracting in the construction industry is one of extraordinary risk. Contractors frequently offer to build something that may be unlike anything they, or anyone else, has done. Moreover, a contractor offers to do this for a fixed price although the contract may take years to complete.

One of the most important factors in the size of the mark-up is the contractor's "hunger" for work. In bidding, a company must consider present work backlog and cash flow needs. The level of demand in a sub-market influences the number of bidders competing for a project. A contractor's willingness to gamble affects how much the company chooses to reduce its bid price to gain a better chance of winning the contract competition.

Fast tracking is a variant of the design-bid-build system. Construction starts as soon as rudimentary engineer-architect designs are completed, saving time as compared to the traditionally sequential design-bid-build method. Contracts of this type are negotiated as "cost plus" contracts.

Design-build, or "turnkey" construction is another form of the negotiated contract. The firm awarded the contract is responsible for both the design and construction of the project. Project delivery is faster than under traditional contracting procedures. One party ensures that the facility meets contract requirements. Coordination between the designer and constructor is easier, and conflicts are more easily resolved because the designer and builder work for the same company. Performance time is decreased resulting in a reduced price. If a contractor completes a project sooner, the variable costs of supervision, labor, and equipment are lower. Negotiated contracts reduce the contractor's risk and the need for contingencies in the bid or proposal. Therefore, the price of construction should be less. Quality should also increase because there is no need to "cut corners" to meet costs or protect profits because of an estimating error. As a result of potential cost and time

savings, government agencies, with prodding by Congress, are using more design-build delivery systems.

Management and Labor

Management in the construction industry is similar to that in the manufacturing industry in some ways. Construction firms fabricate or assemble products as well as install them. What is different in construction is the complex interaction of managers on the project site. A project can have dozens of sub-contractors involved. On site, hands-on job supervision is normally orchestrated by a construction superintendent. The overall project is typically managed by a project engineer. Superintendents are developed and trained through years of experience. Project engineers are developed through formal college programs in architecture, engineering, or construction management.

An overview of employment in the construction industry shows:
- Considerable shifting of employees among work sites.
- Considerable shifting of employees among employers
- Identification by employee with his craft or occupation, not with his employer.
- A relatively large proportion of skilled workers.
- Much self supervision.
- Very unstable employment opportunity.
- Dangerous and often difficult work conditions.
- Intermixture of employees of different employers at a single project site.
- Construction of nonstandard (custom-designed) projects.

There were about 5.3 million workers on construction payrolls in 1994. In addition, about 1.5 million people were self-employed as proprietors and working partners. The construction industry experiences about double the unemployment rate of other industries. Work is seasonal so the percentage unemployed drops in the summer and rises in the winter. While the total number of people employed nationwide has increased, the percent of the work force employed in the construction industry has shown a long-term decline.

Attracting and retaining people of all skills is critical because many people have left the industry during the last two recessions or have retired. Craft training is normally provided by trade unions through apprenticeship programs ranging from one to four years. Associated Builders and Contractors and other non-union contractor associations have expanded training programs to provide skilled craft training.

Non-union contractors grew significantly during the 1980s. The explanation for this varies from outright employer opposition to unions, to the opportunity to secure more regular work from non-union contractors, although at lower rates of pay.

Public Procurement of Construction

Government procedures are designed for full and open competition. Contracts are written in a rigid specification format leaving little room for maneuvering within the specifications. For most public jobs, any contractor meeting minimum qualifications and possessing bid and performance bonds, can bid on a project. The government usually awards the contract to the low bidder. Special approvals are required to prequalify contractors for government projects. Specifications discourage proprietary products in order to encourage competition. Bids are opened publicly; each contractor and subcontractor knows who the apparent low bidder is and the price submitted by each bidder.

Public sector construction contracts contain additional requirements as a matter of social policy. The additional requirements include application of the Davis Bacon Act and requirements to contract with or employ small business, minority owned firms and women owned firms. The Davis Bacon Act requires the area's prevailing wage rate be used. Depending on the location, the act may increase craft labor costs. Moreover, it increases direct project overhead by requiring additional record keeping.

Government Regulations

The construction industry is moderately regulated at the federal level. The Federal Government also regulates the industry with respect to certain aspects of business performance. These include wages, work hours, labor relations, employment discrimination, environmental pollution, workplace safety, product safety, trade practices, and industry structure. When federal funding is involved in a project, the construction industry is heavily regulated.

State governments play a role in implementing some Federal regulatory programs. States also act on their own authority to regulate certain industries including the construction industry. Regulatory policies vary widely from state to state. There is considerable regulation of the construction industry in the form of local ordinances concerned with building practices and standards, health and sanitation, and land-use planning and zoning.

Federal, state and local regulations impact project owners through land-use planning, zoning, and siting requirements. One way owners are regulated is through the National Environmental Policy Act of 1969 (NEPA). NEPA states that any action (including construction projects) that has any federal impact must address those impacts through an appropriate level of environmental analysis and documentation. The results of the analysis might identify impacts that limit what the owner can construct and its placement on the site. The impacts could result in increased construction costs because of the requirement to mitigate environmental consequences of the project such as relocating endangered species habitats or

replacing protected wetlands areas.

In addition to the added costs of mitigation, the owner must also fund the environmental analysis. The analysis could cost over a million dollars depending on the scope of the construction project and whether a full-scale environmental impact statement is required. From the owner's perspective (especially that of Federal agencies), this environmental analysis requirement is costly in manpower and dollars, but even more costly in increased time to procure and occupy the project. Overall, this regulation results in limiting lands available for new construction.

Federal regulation of the contractor concentrates on labor and ensures the existence of a safe and healthy environment as well as fair and equitable wages if Federal funds are involved in the project. The Davis-Bacon Act, enacted in 1931 during the great Depression, was designed to protect local businesses from being underbid by low-wage workers from out of town. The Congressional Budget Office estimates that the Davis-Bacon Act raises Federal construction costs nearly $1 billion a year.

The Occupational Safety and Health Act (OSHA) is not construction specific but has several construction related sections. Application of OSHA standards increases project costs that are eventually passed on to the owner. It is possible that this results in projects becoming too costly for some owners resulting in a reduction of the construction market.

INDUSTRY TRENDS

Trends in Technology

Fragmentation of the construction industry makes it difficult to introduce technological innovations. However, one area that technology is taking hold is computer software designed to replace manual methods in bid proposals, estimating, scheduling, construction control, and project control/management. These advances in computer-integrated construction allow the construction industry to automate databases, control and standardize design and engineering concepts, and transfer this data electronically. Several firms visited pointed out that the use of software and computers allow construction estimates and design to be done away from the job site, even out of the country, by lower wage personnel.

The construction industry is peculiar in that it is the agglomeration of many diverse trades which uniquely converge one project at a time. The application of new technology varies project by project. Construction techniques vary by country, region, geography, and climate. Rarely does the benefit of research and development (R&D) transfer across projects. Often the fragmented, adversarial, and litigious relationships and the rigid design-bid-build delivery systems inhibit the introduction and sharing of

R&D innovations.

The Federal sector provides 63% of all civil engineering R&D related funding. Industry funds 16%, Academia 12%, State Government 4%, and Non-Profit Organizations 4%.[1] Industry spends only 9% of its R&D dollars in basic and applied research whereas the Federal sector spends 52%. Industry, on the other hand, invests where it can realize immediate return on investment; in development, demonstration, and innovation R&D.

Most construction industry R&D is accomplished by manufacturers of construction products rather than by design and construction firms. Three factors that affect the level of R&D investments are: (1) potential future earnings and profit, (2) desire to keep the leading edge, and (3) growth objectives.[2] Two inhibiting factors are: (1) inadequate staff and resources, and (2) the cost of R&D.

Public-private sector cooperation in R&D is the norm in Japan and most Western European countries. This public-private relationship is a strategic cornerstone that facilitates development of national objectives, enhances coordination, and efficiently uses scarce resources. For example, Japan uses its fiscal policy to tax and provide tax breaks to encourage R&D. The Japanese Government product approval process supports domestic innovators and acts effectively to discourage foreign competitors. Japanese strategic vision of 20 years and vertical integration ensures application of R&D results. Sweden serves as an excellent example of R&D cooperation among industry, academia, and government. Responsibility for research and development resides under the Ministry of Industry and Commerce (MIC). The Swedish Council for Building and Research is funded by MIC, local governments, research institutes, and industry.

Established procedures for R&D evaluation that minimize liability and risk for both the public and private sectors are central to civil-engineering related R&D in Japan and Western Europe. The potential of liability litigation is seen as a significant barrier to innovation among U.S. design and construction firms.

Civil engineering related R&D in Japan and Western Europe focuses more attention than U.S. firms on life cycle performance and life cycle costs. Contracting practices such as functional specifications, prequalification, and best bid encourage this type of research.[3] In Western Europe and Japan, each of the largest top 10 contractors have their own R&D labs as opposed to none of the top 10 U.S. contractors.[4]

Swedish contractors are reported to reinvest 1.6% of their construction turnover into R&D. The construction industry has requested government imposition of a payroll tax of $0.03/labor-hour, paid into a development fund, to support R&D.[5]

In 1992, federal R&D spending in the U.S. was $1.3 billion, in Japan $1.2 billion, and in Germany $1.2 billion.[6] U.S. industrial firms invest on the average of 2.5% of sales in R&D whereas the U.S. construction industry spends 0.5%, Japan 3.0% and Western Europe 2.1%.[7] The U.S. construction industry private sector spends less on R&D than its Japanese and European counterparts. However, the United States leads in the development of high performance concrete, waste/waste water treatment systems and applications, Computer aided design/ Computer aided engineering (CAD/CAE) development, solid/hazardous waste disposal, environment, GPS/GIS, and development of integrated databases.

Europe has focused on development of high performance asphalt, building high-speed rail and magnetic levitation, tunneling, GPS/GIS, historic restoration, marine construction, and energy conservation. Japan has focused on development of high performance steel, automated equipment, field computer use, high speed pavement assessment, safety, intelligent buildings, and building systems.[8]

For the future, composites appear to provide alternatives to conventional wood, steel, and concrete. They are corrosion resistant, light weight, high strength, low maintenance, and provide for oriented strength, design flexibility, and component consolidation. An alternative to composites are hybrids. They are formed from the combination of traditional materials with composite laminates.[9] This is an area that we see great advantages for the United States in the future.

Defense Related Construction

The industry is not dependent on the influx of military or defense projects to keep it alive. Military spending in 1988 was $3.6 billion and is falling to a forecasted $2.4 billion in 1995, less than 1% of the entire construction value for those years. With limited exceptions (ordnance and explosives ranges), the types of facilities designed and built for the military are comparable to those of the non-defense community. Few special skills have been developed that would be lost if contractors who perform defense design and construction work converted to non-defense work.

Productivity

The U.S. construction industry is highly competitive, operates on small profit margins, involves high risk, and is highly dependent on cash flow. In this environment, productivity and efficiency are critical measures to gauge success. Productivity is enhanced through the use of CAD/CAM and other automation techniques in the design, construction, and management phases.

Measuring productivity accurately is not an easy task. Input factors such as design quality, scheduling, site conditions, material availability, weather, and worker motivation interact differently from project to project. To complicate matters, output

varies by project--the final product is always different.

Architecture and Engineering firms who make money by winning design contracts may simply measure sales per number of employees. An increase in the dollar value of designs under contract (either more contracts or bigger jobs) with the same number of engineers represents increased profit and sales. This is how one major firm visited measures productivity. Construction management firms may measure actual schedule versus planned schedule or actual cost versus budgeted cost. These measures reflect how well the overall construction effort is managed. General contractors who have the most at risk in a project are interested in actual costs versus budgeted costs as well as functional work units per manhour to finish the work. This last measure reflects actual job site performance. Subcontractors use similar measures.

According to the industry representatives we visited, the key to improving efficiency is to improve individual processes. World class firms use quality management techniques to improve and stay competitive. In addition to the use of metrics such as material delivery, material marking and labeling, and the number of job site changes, construction firms are finding another principle of total quality management valuable in improving productivity--the concept of getting to know the customers better. A similar process achieving good results is the concept of partnering. Keys to the partnering process include partners (usually the owner and the contractor) getting to know each other at a partnering skills workshop; development of mutual goals for safety, quality, schedule, etc.; and agreeing on an issue resolution procedure. This process often results in significant value engineering proposals, change orders without claims, and elimination of letter writing campaigns. The bottom line is a more timely product at a lower cost.

International Competition

The international construction industry is comprised of those architectural, engineering and construction firms who compete for major projects in the global market. The United States has historically been the biggest player in the international construction market and continues as such. However, market share has declined from a high of nearly 70% of billings following World War II to approximately 40% in 1993.

The U.S. strength in this market is large scale design and construction know-how developed from highly specialized technical engineering projects where experience plays the deciding factor. Market share has been lost primarily in the highly competitive general building and heavy construction, where a smaller competitive edge exists for the U.S. These are projects of a conventional nature which use standard equipment and construction support services.

The majority of firms competing in the global market represent a small number of countries but account for 85% of the international construction trade. The competitive advantage of these firms is often based on their national government's willingness to implement foreign and domestic trade policies designed to provide them a competitive edge.

Countries with whom U.S. construction firms compete include a recurring list of players who are increasing their market share at U.S. expense. South Korea, Japan, France, Italy, Canada, and the United Kingdom are the notable competition for the United States.[10]

Asia is by far the most dynamic market and has shown consistent growth over time, including 21% more new contracts in 1993 than in 1992. Many large international construction firms are betting that Asia is the one market to be relied on for strong future growth. The direction is also more towards highly sophisticated petroleum and petrochemical plants and less to general large scale projects.

International trade and capital flows have become important factors in the domestic construction market. Because of record levels of foreign investment in the United States, an increasing share of U.S. construction projects have been built for foreign owners. Foreign direct investment in the United States has been primarily in manufacturing facilities, warehouses, office buildings, and hotels.

Many of the world's largest foreign construction contractors entered the U.S. construction market during the 1980s and are becoming a significant factor in nonresidential construction. Most contractors enter the U. S. construction market by purchasing U.S. construction companies. Some of the largest foreign contractors have, however, established their own operations in the United States. Foreign-owned construction firms won about $12.3 billion in U.S. construction contracts in 1991, which was down from the record $15.5 billion in 1990. Most of these foreign entrants are based in Germany, the United Kingdom, Japan, and France, although nearly a dozen additional nations are represented.

MAJOR CHALLENGES IN THE FUTURE

Events occurring today impact the construction industry of the 21st century. Current major issues involve tort and regulatory questions, workforce size and quality, and the proper assignment of responsibility and risk. Regulations and the threat of litigation make it difficult and costly for firms in the construction industry. Different demands will be placed on the workforce in the construction industry of the future. Construction cost and responsibility will require methods of creative financing as well as consideration of new construction methods. The industry must address several issues to ensure its future viability.

-- Educating and training new workers for entry into the construction trades is critical. Although wages are better than many other industries, construction jobs have lost their glamour and are not attracting new entries into the skilled trades.

-- Because of the increasing demands of a highly competitive global economy, employers are having increasing difficulty finding workers with the academic, analytical, and technical skills they need. The United States, unlike some Western European countries and Japan, does not have an organized, comprehensive system to help young people prepare for and enter the workforce. Apprenticeship programs are the only channel of entry into most of the skilled trades. These programs vary in quality and scope and suffer from the irregular flow of work in the industry.

-- The construction industry must achieve increased worker productivity. Fundamental changes in work execution and new/improved work processes must be considered. Firms and workers must recognize the need for new skills including the ability to address technical, economical, environmental, societal, legal, and aesthetic concerns.

-- Contractors, engineers, architects, subcontractors, and suppliers who make up the delivery team for the construction project will have to cooperate more closely to improve quality.

-- The industry must provide quality facilities in a shorter time. Potential methods include development of multi-disciplinary teams, including non-technical disciplines and the use of design-build, partnering, etc.

-- To remain competitive, the industry must capitalize on automation and capital intensive technology; promote the introduction of new materials; emphasize greater use of recycled materials; recognize that environmental regulations are here to stay and incorporate environmental components in each project; and recognize total quality management with ISO 9000 certification as a requirement.

-- Understand the current trend toward consolidation into larger companies and development of niche players with mid-level firms being forced to merge or step down.

-- Accept that globalization will play a bigger part in the construction industry in the future. This requires recognizing barriers such as language, standards, and certification and addressing issues such as tapping low-cost markets through the use of international engineering and construction labor. Through enhancements in communication and software, sharing of construction processes throughout the world will be the norm. A concentration of Computer aided design (CAD) work for major international projects is currently taking place in Southeast Asia and the India subcontinent.

-- Environmental regulations are providing business opportunities for engineering and construction companies. For some companies such as Parsons-Brinckerhoff, it has resulted in having a separate division fully trained, equipped, staffed, and functioning to ensure products meet or exceed compliance standards. Other companies like Law Engineering or Dames Moore are providing these services to other organizations. For most of the industry, reliance on outside environmental vendors is a necessity because large dollars are involved. Issues to be addressed include dealing with contaminated lands called brownfields.

International construction is a big industry with relatively few players. Fewer than half a dozen countries control more than 75% of the market. With the exception of the U.S., and to a lesser extent Canada, all countries provide varying degrees of government support to their construction industry. In the case of France and Japan, this gives their firms a considerable competitive edge. By contrast, in the U.S., Federal law prevents U.S. companies from bidding in countries with traditional communist ties or countries with human rights violations. Export licensing also makes life difficult for U.S. firms when shipping technology or products to countries other than Canada. These delays increase costs and result in lost opportunities. The classic example of export controls hampering and limiting U.S. market participation is the nuclear construction industry.

Another factor that greatly influences competitiveness of U.S. firms is the tax code. The U.S. is the only country with taxes based on citizenship and not on location of domicile. The good news is that some government support exists. Two government institutions that have had a positive influence on U.S. international construction are the Army Corps of Engineers and the Department of Interior's Bureau of Reclamation. Both agencies work closely to get international projects awarded to U.S. firms.

ANALYSIS AND RECOMMENDATIONS

The world is in a transition period influenced by the end of the Cold War. It is experiencing exponential growth in telecommunications and information services, recognition of environmental issues, and adjustments in populations around the world. While these changes have little direct impact on domestic construction, the construction industry of the 21st century will be influenced by global events unless artificial barriers are established. As several CEOs of major construction firms have told us, the construction industry is extremely competitive around the globe. To remain competitive, firms must look into the future and correctly assess the implications of changes in the industry.

Industry

To survive in the future, construction industry leaders must recognize and

consider the following:

-- Educate and empower the workforce to improve quality. ISO 9000 quality management certification requires this. Construction will always need rugged individuals who become iron workers, plumbers, carpenters, welders, etc. and who enjoy just plain hard work in all kinds of weather. However, the use of new materials including composites, new types of fasteners, and computerized tools and equipment require workers who can operate sophisticated equipment and assemble new materials. The key will be training and education. As new processes are developed, there will be a need for a work force that is more multi-skilled. For example, in the future, carpenters, masons, and metal workers may become structural assembly technicians. Construction companies, contractor associations, and unions will need to work together to provide the training to ensure skill development. Closer cooperation with education and government institutions to promote career opportunities in the industry will be required.

-- Focus company strategy, operations, and employees on the customer. Understanding the customer base and the various market segments within the base provides companies with the best clues for maintaining and expanding market share both domestically and internationally. It also ensures concentration of resources into areas where true market needs exist. Companies must strive to perform work right the first time, and know that improvements must be continuous.

-- Invest in the workforce by grooming employees with management potential. Construction managers must conduct a good analysis of labor needs during the planning stage of a large construction project and then ensure quality labor is hired. For example, the construction management firm for the Boston Harbor Sewage Treatment Plant Project negotiated a labor agreement with the Building and Construction Trades Council of the Metropolitan District in Boston. As part of the agreement, a transportation plan, an eight-hour work day, stabilized wage rates, and a set travel time allowance were defined. The objective of the labor agreement was to prevent work stoppages during the project. Establishing terms early in the process mitigated labor problems over the course of the project.

-- Hire contractors to develop construction management programs with business and supervisory training to augment technical training and experience. Owners of large construction projects are taking advantage of construction management firms. The construction management firm is a rearrangement of the traditional relationships using more scientific management techniques to improve cooperation and control of the planning, designing, and construction processes. The rapid expansion of large firms offering construction management demonstrates the market demand.

-- Use technology developed by Federal programs, other nations, and educational institutions. This includes information services, engineering software, construction

methods, construction materials, and construction equipment.

-- Develop fair methods for assigning risk and sharing the cost of construction. Design-build, partnering, user fees, and private ownership of public projects are among methods to be considered.

-- Develop a full cycle (design, build, operate, maintain, transfer) construction approach that provides low cost, efficient, and environmentally acceptable projects.

-- Introduce tort reform, personal responsibility, and reduced litigation through mandatory alternative disputes resolution devices.

-- Eliminate environmental service vendor inconsistencies with respect to fees and standards of performance by establishing a certification criteria. Vendors are being paid a fee to assist companies in attaining and maintaining environmental standards. Vendors should be held accountable to an industry-wide code of ethics.

-- Develop risk assessment practices based on future land use.

-- Use revised brownfield soil sample procedures. Rather than taking samples on predetermined intervals, the samples are taken where the actual hazardous waste is located and then randomly where required. Soil samples from the known hazardous area vice the entire expanse of land will ensure the remediation effort is focused only on the brownfield contamination and avoid unnecessary sampling and remediation costs.

-- Support national civil engineering-related R&D efforts thereby gaining greater control over resources and becoming less dependent on the Federal sector.

-- Develop an accurate means of tracking true civil engineering related R&D costs in order to better evaluate its effectiveness on productivity.

-- Use creative contract practices like design-build that facilitate the incorporation of new technologies throughout a projects entire life cycle.

-- Participate in more public and private R&D consortia on a cost sharing basis.

-- Fund students at the college and VOTECH level to create a supply of workers capable of creating end use innovation.[11]

-- Assist in developing improvements to project delivery policies that are barriers to innovation.

-- Support and guide research at universities and professional organizations, like the

Civil Engineering Research Foundation.

-- Seek cooperative R&D agreements with national labs.[12]

-- Increase productivity through the development of composites that are cheaper, more durable, and easier to maintain than conventional materials or structural components.

-- Identify types of existing civil engineering structures that can be restored, upgraded, or replaced by incorporating innovative, but existing and proven composite technology.

-- Focus on areas of civil engineering where traditional materials are deficient and where the need for enhanced performance is greatest(e.g. bridge decking).[13]

Government

Ensuring a viable construction industry into the 21st century requires the government to:

-- Commit funds consistently for public works projects.

-- Provide adequate and stable funding for applied research and demonstration projects.

-- Provide an environment that encourages technology transfer, stimulates innovation, and promotes investment in technology-related industries. This can be accomplished through the creation of centers of excellence and other joint initiatives by state or local governments, regional organizations, or Federal laboratories.

-- Identify and promote areas in the industry that need to be improved and cooperate more closely with the materials and machinery industries to foster innovation.

-- Reexamine current regulations and laws to simplify and remove potential barriers in the industry.

-- Labor laws should be reexamined to see if they are still needed.

-- Environmental regulations, while important in achieving clean air, clean water, and protecting our natural resources, must strike a reasonable balance with future development. Policy should be changed to one that requires lands to be cleaned to standards commensurate with intended future use vice a prescribed environmental standard.

-- Streamlining the permitting process could dramatically assist the industry by reducing the time from project conception to completion.

-- Safety regulations need to be reviewed to ensure the government has not created unnecessary barriers to job site productivity.

-- Local governments can help productivity by reviewing local building codes for currency and applicability as well as streamlining their permitting procedures.

-- Reform the collective bargaining process. One way is to simplify and generalize the content of the agreements. The process must be changed so employers do not view the relationship between construction firms and unions as adversarial and the collective bargaining process as too bureaucratic.

-- Reform tax structure to provide incentives for firms developing new processes.

-- Promote development aid following the same course as that of other nations: tie a portion of aid to the purchase of U.S. export and services. Tax incentives should also be pursued as the U.S. is the only country that taxes its citizens without regard to domicile; this reduces U.S. profit margin and competitiveness.

SUMMARY

The domestic construction industry is a critical foundation supporting the quality of life of the American population and provides a significant part of the infrastructure of the American economy. Changes will take place in the construction industry because of changes in population demographics, the need to provide quality and timely projects and facilities, downsizing of government, and the advent of new technologies. The changes in the industry can have an impact on United States national security strategy and must be understood. At the present time the industry is in a strong position. Encouraging new ways of doing business, cooperative partnering between government and industry and within the industry, education of the industry, removal of intrusive aspects of regulations and laws will go a long way toward maintaining the viability of this industry.

ENDNOTES

1. "A Nationwide Survey of Civil Engineering Related R&D," Civil Engineering Research Foundation, December 1993, p. 47.

2. Ibid, p. 20

3. Ibid, p. 48.

4. "The Futures of Composites in Construction," p. 5.

5. "Constructed Civil Infrastructure Systems R&D: A European Perspective," Civil Engineering Research Foundation, 1994, p. B-10.

6. "A Nationwide Survey of Civil Engineering Related R&D," Civil Engineering Research Foundation, December 1993,p. 48.

7. "The Futures of Composites in Construction," p. 5.

8. "Constructed Civil Infrastructure... European..." p. 5.

9. "The Futures of Composites in Construction," p. 4.

10. United States. Department of Commerce
A Competitive Assessment of the U.S. International Construction Industry 1989 Edition. Washington: International Trade Administration, 1989. pg 38-57.

11. "A Nationwide Survey of Civil Engineering Related R&D," Civil Engineering Research Foundation, December 1993, p. 52.

12. "White House Construction Industry," p 13.

13. "The Futures of Composites in Construction," p. 5.

INDUSTRY STUDY

#7

EDUCATION

TABLE OF CONTENTS

PARTICIPANTS

Students

Mr. Victor J. Bonilla, US Department of State
LTC Mark S. Borkowski, USAF
LTC Gary S. Connor, USAF
LTC Dale R. Granger, USA
CDR Kathryn M. Hobbs, USN
CDR Susan Maybaum-Wisniewski, USN
LTC George J. Nixon, USAF
Mr. Joseph G. Obermeier, Defense Mapping Agency
LTC Larry J. Olson, USA
CDR David M. Perdue, USN
CAPT Robert Ranquet, DGA, France
Mr. Wilson Summers IV, Defense Systems Management College
CDR Steve Waite, USN
LTC Charles R. Walker, USA
LTC William A. Weir, USA

Faculty

Dr. John E. Bokel, Professor of Industrial Mobilization
Mr. Francis W. A'Hearn, Professor of Acquisition
CAPT Samuel Apple, US Coast Guard, Professor of History
COL Joseph Ross, USA, Professor of History
COL James L. Narel, USA, Professor of Organizational Management

GUEST SPEAKERS

Dr. Gerald Bracey, Research Psychologist and Author
Mr. Denis Doyle, Hudson Institute
Dr. Robert Leestma, Consultant
Ms. Anne Lewis, Author and Columnist, Consultant

PLACES VISITED

Domestic

Fairfax County Public Schools	Fairfax, VA
Thomas Jefferson HS for Science and Technology	Alexandria, VA
Maryland State Department of Education	Baltimore, MD
Education Alternatives, Inc.	Baltimore, MD
National Education Association (NEA)	Washington, DC
Dept of Education, Office of Educational Research & Improvement	Washington, DC
Department of Labor	Washington, DC
AFL-CIO	Washington, DC
Chrysler Technical Design Center	Detroit, MI
Project Focus Hope	Detroit, MI
Xerox Document University	Leesburg, VA
Designs For Change	Chicago, IL
Corporate Community Schools of America	Chicago, IL
Hefferam Elementary School	Chicago, IL
Motorola University	Chicago, IL
DeVry Technical Institutes	Chicago, IL
US Military Academy at West Point	West Point, NY
Bank Street Teachers' College	New York, NY
Christopher Columbus Middle School	Union City, NJ
Educational Testing Service	Princeton, NJ
The Business Roundtable	Washington, DC
Department of Labor, Region One	Boston, MA
New American Schools Development Corporation Project	Boston, MA
Minuteman High School	Boston, MA
Northern Essex Community College	Boston, MA

International Travel

UK Ministry for Education	London, England
UK Ministry for Employment	London, England
Enfield County School	London, England
London Tech Projects (CENTEC)	London, England
German Ministry of Education	Berlin, Germany
Federal Institute for Vocational Training	Berlin, Germany
Vocational School of Precision Engineering	Berlin, Germany
Ford Motor Company	Berlin, Germany
OECD	Paris, France
Ministry of Education	Paris, France

OUR VISION

The world's premier education and training system--based upon American values, strengths and diversity--enabling America to remain the global leader in the highly dynamic world of the 21st century. A highly flexible life-long learning environment that promotes equity and personal, community, and national responsibility, while ensuring comprehensive and affordable opportunities for all. A system that provides the supporting foundation for our National Security Strategy, that provides quality of life opportunities, and that helps our Nation meet its future challenges.

- ICAF Seminar 11

EXECUTIVE SUMMARY

As America experiences the technological and global economic revolutions of Alvin Toffler's "The Third Wave," our nation is struggling with the issues which threaten our position of global leadership. Sustainable levels of affordability and increased competition in terms of value, quality, speed and price are driving American public and private sectors to re-examine the manner by which they have conducted business in the past. Work, as we know it, is being redefined on a daily basis. Yet one theme remains constant--competition will drive every aspect of the process.

As the Workplace of 2005 continues to evolve in response to increased market pressures, corporate America has recognized the need for a quality workforce. Although many authors have described the educational needs and the skill requirements of our future workforce in a variety of ways, they boil down to *six key characteristics.* The workforce of the future will need to come prepared with a *core of basic knowledge*; the ability to *think analytically and creatively;* a *familiarity with technology*; an aptitude for *interpersonal communication*; an understanding of the *role of learning;* and a *strong set of personal values.* Consequently, industry is demanding improved performance and increased accountability in our education and training systems. In response, schools have begun to assess the future educational needs and skill requirements of a competitive America and adapt at the state and local level. Industry is beginning to accept its role in the process by cooperating with schools to lay out a path to work which can begin to tie learning to earning. And finally, standards and certification requirements in specific occupations will provide the means to assess qualifications and to target education and training in the workplace. <u>*In the end, the concept of life-long learning is evolving as the critical ingredient to our nation's economic success and ultimately our national security*</u>.

OUR GOALS

As senior level public service officials, our primary objective this year was to gain an executive-level perspective of the U.S. education industry's capability to provide a qualitatively superior workforce for the 21st century. Our study examined public and private schools from preschool to post-graduate education, vocational and technical training, and workforce and industry training programs. Our goals were:

*To analyze specific aspects of the education industry such as:
- Structure, practices, processes, and systems
- Measures of performance and trends
- Current and future strategies
- Government policy initiatives.

*To analyze workforce requirements to identify how best to maintain a world class economy and a viable defense industrial base.

*To assess U.S. competitiveness by comparing American education and training systems with those in other industrialized countries.

*To evaluate Government policy for education and training and recommend options for improving U.S. economic competitiveness and fostering success in defense industries.

*To review and analyze how education "fits" into the national security strategy, as well as education's fundamental impact upon resource allocation and strategy execution.

COURSE OF STUDY

Our examination of the education and training industry was conducted from multiple viewpoints to understand better the complexity of the challenge facing America today. We reviewed the issues from the perspective of educators--school teachers and administrators on the front lines of schools today. In addition, we discussed the needs of the commercial community with today's business leaders who employ our students. In our review, we also heard from the nation's critics, as well as the advocates of American education and training-- those observers and consultants seeking to identify the sources of current problems and trends in education and offering recommendations for reform. Lastly, we interviewed government and union leaders to determine the critical issues facing our education and training systems from a national perspective.

ACTIVITIES

The core of the Education Industry Seminar focused on the review of a common body of relevant literature while participating in formal seminar discussions. Individual participants in the course selected particular issues or areas of study for research and produced reports which were reviewed with other members of the class. The resulting information provided the foundation for this report.

In addition, seminar members hosted a series of lectures by visiting distinguished guests who are experts in the fields of education and training. Following each lecture, students had the opportunity to discuss the lecture, as well as other insights related to the field.

The location of the Industrial College of the Armed Forces offers direct access to our nation's senior leadership. As a result, the education seminar exchanged visits with numerous senior officials from federal, state and local governments dedicated to providing world class education and training opportunities. National labor and teacher unions were visited to gain a better understanding of those operating within the industry.

Visits outside of the Washington area were conducted to six major urban areas: Baltimore, Detroit, Chicago, New York, New Jersey, and Boston. Discussions were held with leaders of education in both the public and private sectors of the economy. Innovative alternatives to traditional approaches to education and training were sought out and reviewed in detail. In addition, the seminar was able to visit senior leaders in the post-graduate academic community who train the teachers of tomorrow's workforce. Vocational and technical institutions were visited to discuss current efforts to improve the technical capabilities of those not pursuing the traditional academic path. Industry leaders, dedicated to improving the quality of America's workforce, were sought out to examine the role of business as partners in educating and training our workforce.

Finally, an international perspective was gained by visits to England, Germany, and France to benchmark America's system against those of other global competitors. Societal differences were examined in order to identify similarities and differences between and among the systems. Alternative approaches, to include public and private education programs, high-tech industry training, and vocational apprenticeship programs were reviewed.

HOW THIS REPORT IS ORGANIZED

Our analysis of the Education and Training Industry centered on three "pillars"--the school pillar (elementary and secondary schooling), the transition pillar (bridging the gap between schooling and the workplace), and the workplace and life-long

learning pillar (where employers educate and retrain the workforce and where people continue their own personal learning journey). For each pillar, we examine the structure, conduct, and performance of that segment of the industry and address general conclusions. The paper then offers an assessment of trends and issues across the entire industry, and concludes with recommended education strategies for the year 2020.

THE SCHOOL PILLAR

Education in the United States consists of three levels of formal education: ***elementary, secondary, and postsecondary***. This section deals with the school pillar, the elementary and secondary school levels.

Structure

There are over **49 million students** enrolled in elementary and secondary schools as of 1992. Projections for the year 2004 indicate we will have over 57 million (14% increase) enrolled in the United States education system.

The elementary and secondary school system in the United States includes 84,578 elementary and 59,258 secondary schools employing over 2.8 million teachers. Also included in the nation's primary educational structure are over 15,000 local school districts or boards (1992 Department of Education data, National Center for Education Statistics). This nation spent over **$500 billion** in 1992 for education from elementary and secondary schools on through post-secondary education and college.

Before entering the formal education system, some students may attend nursery school for one or two years. Many states now require students to enter kindergarten at age five as a prerequisite for entry into the first grade.

The education system uses a ***vertical approach*** for education in grades one through twelve. The United States elementary and secondary education system allows three choices: ***public school, private school, or home schooling***.

Local policies and student population densities determine the separation line between elementary and secondary levels of education. Many school districts separate their elementary students at grade six and establish junior high schools for grades seven through nine. Students will complete their secondary education at senior high schools for grades ten through twelve.

The more densely populated school districts may establish elementary schools for grades one through four. Students then transfer to middle school for grades five through eight, followed by four-year high schools, grades nine through twelve.

The smaller school districts normally combine junior and senior high school so that students may attend only two schools in their lifetime. However, there are still small community schools in the United States where students attend all grades at one school.

The ***primary curricula are reading, writing, and arithmetic***, with no standards required nationally or by state. Local schools or school districts decide what curriculum and methods of teaching best suit their specific student needs.

Vocational and technical schools are part of the postsecondary education system upon completion of high school, but little high school preparation is made for students wanting to enter these areas. Unlike other nations, we do not place a premium on vocational and technical training in our secondary education system. Students who elect to pursue a vocational training track are the exception.

Conduct

Given the nature and structure of our educational systems, they are very slow to change. The U.S. Constitution does not specify a federal role in education, leaving the matter to the discretion of the states. The lion's share of ***funding for schools comes from local and state sources,*** with the Federal Government contributing less than 10 percent. The governing of local schools is normally carried out through local school boards or districts, with board members locally elected or appointed.

Due to the variety of interests of key players in education (students, parents, teachers, administrators, community leaders, tax payers, businesses, unions, and government), ***change is often the victim of political interests which can impede progress in bringing about reforms.***

The education system is not only slow to change, but it is seen by many as devoid of any relationship to the labor market. Since any change must be long-term and requires many years to yield results, it is not surprising that changes come slowly. Unlike other industries, education does not respond to market influences, leading American and foreign industries to complain that our education system isn't producing students capable of operating in the global and transnational world of the 21st century.

Given the local nature (i.e. control, funding decisions, etc.) of education, it is not surprising that national standards are absent. Growing concerns raised as a result of numerous studies have given rise to reform movements nation wide.

The national **debate** has centered on: identification of ***standards and accountability, redefining the purpose of our schools, parental involvement and the 'taking back' of schools, community involvement, and business identification of educational requirements.***

Changing demographics, ethnic diversity, migration, immigration and birthrate patterns give rise to new educational requirements. Technology is influencing the methods and substance of teaching and how we prepare both the classrooms and educators for their new roles. Accompanying these changes are the age old problems of rising costs, cost-benefit analysis, and new investigations into reducing the cost growth while we professionalize the teaching profession.

Performance

It is a widespread perception that our country's most valuable and ***critical resource***, OUR PEOPLE, and the school systems which provide the learning process are not reaching their full potential. Students are graduating from high school without the skills needed to function in society or enter the job market. Subsequently, they are unable to meet the fast paced changes in the world economy.

The National Security Strategy has as one of its goals, ***"bolstering America's economic revitalization."*** This goal cannot be achieved without a quality workforce educated, trained, and prepared for the jobs necessary for a high quality competitive work environment.

No manager or administrator can effectively run any organization without timely and accurate information about its performance relative to its goals. But on several, if not all, levels of the American education system, the absence of good performance measurement seems to be the norm and not the exception.

Although there are numerous indicators diagnosing the health of the educational system, they are often confusing and difficult to access. Examples: One report states that U.S. students rank ***49th in literacy*** (reading and writing proficiencies) when compared among students from 158 member states of the United Nations. The scores of U.S. bound college students in biology, chemistry, physics, and several areas of mathematics are constantly in the ***lower fourth of scores*** when compared to students in other major industrialized countries. On the other hand, data from the National Center for Education Statistics show noticeable improvements during the last decade in science and mathematics, while trends for reading show declines during the same period. There are perennial articles, commentaries, and news shows depicting chaos and degeneration of our educational system. ***What is really happening and should we be concerned?***

There are numerous success stories throughout the educational system about schools that are extremely effective and fully utilizing all their resources. These **'good schools'** appear to share a number of common elements: the desire and ***ability to change*** the status quo, ***strong leadership***, dedicated teachers and staff, family and *neighborhood* ***involvement***, and ***sufficient resources*** necessary to provide for a productive learning environment. To the extent that these elements are not present,

the probability of success is diminished.

Unfortunately, in many school districts throughout the United States, one or several of these critical elements is missing. This is especially true in economically disadvantaged areas. As the percentage of minority students increases, the gulf widens between those students that have access to the previously mentioned elements and those that do not. Students in urban schools experience the telling signs of decline due to the drop in the tax base necessary to provide the resources, the deterioration of the family structure, crime/drugs, and the absence of good role models.

These students represent the work force of the future and their ability to fill the jobs that will be necessary for the industrial base and national security of this country is in jeopardy. Although there is concern with the performance of the educational system in general, the crucial aspect putting this country at risk in the future is the preparation and education of these students.

Conclusion

- Unlike many other industrialized countries, the United States does not have a centrally-managed school system administered by a national bureaucracy. Consequently, national standards exist only to the extent that regional school accreditation boards require them for recognition of a degree from an educational institution. States and local bodies, such as school boards, define the curricula.

- Funding for education emanates primarily from state and local sources and the Federal Government contributes less than 10 percent of funding nationwide. Many communities rely on property taxes to support their schools. Businesses, whether local or national, provide an insignificant fraction of the costs associated with educating our nation's youth. However, some corporations are at the forefront of funding for new and innovative demonstration programs.

- The accelerated changes about which futurist Alvin Toffler has extensively written imply that education and the rate we acquire knowledge will play a critical role in defining a nation's wealth in the 21st century.

- The successful schools we visited all shared certain qualities:

-- Community participation by administrators, teachers, staff, parents, students, and community organizations on a daily basis in providing a total and safe learning environment.

-- Curricula that are tailored for a diverse student population and that provide the needed flexibility to adapt to differing learning abilities and styles.

-- Increased autonomy at the local school level that allows each community to define its needs and requirements within broadly defined curricula.

-- Increased accountability at the local level for the pedagogic style and criteria utilized by schools.

-- Devolution of responsibility to the school community as the arbiters of change. This means that earlier involvement by students and parents in the career of the future breadwinner will be dictated by the degree of motivation supporting the reforms.

-- High expectations leading to improved performance. We repeatedly saw the impact a well motivated and dynamically-led staff could have in turning around even the worst inner city schools.

-- Businesses and other private elements of the local school community played a significant role in the improvement of the schools once they became involved in the process.

The increased fragmentation of our society poses new threats, but also opportunities for growth. Schools are at the leading edge of change and will demonstrate the degree of national and local commitment to our future.

THE TRANSITION PILLAR

In this section, we will briefly review the second of the three structural components of education and training: the **transition** pillar. This pillar bridges the gap between primary and secondary schooling and the workplace. It also is the vehicle which facilitates the transfer between the adult employment and re-employment. This transfer is broadly construed to include transitions not only from job to job, but also from career to career, or from career to retirement.

Our first segment describes the structure of each of the two transition components: school to work and employment to re-employment. Then, in a following segment, examples of behavior within each component are addressed as a mean of outlining market conduct. In turn, a third segment considers the performance of second pillar organizations, public and private, which serve the transition function. A concluding segment then ties together our review of the Transition Pillar by way of a strategic assessment of the trends, challenges, and issues with which it must concern itself in the turn of the 21st Century.

Structure

The Department of Commerce estimates that nearly **$530 million** are spent on education and training in the United States each year. Approximately **$200M** of this is

spent on non-corporate education beyond high school, to include both public and private vocational programs, junior colleges, and four-year college degree programs. If we define the transition pillar as including both public and private efforts to bridge secondary education efforts with the world of work, expenditures would be somewhat higher, but not significantly so. Federal, state, and local governments provide approximately **four-fifths** of the total expenditures; private enterprises provide the rest.

The "transition pillar" includes several traditional categories of education and training providers: high schools (in their school-to-work programs); apprenticeship programs; community and technical colleges; and private vocational and proprietary schools. Prominent programs in these areas initiated as a result of public policy include, in part, the Job Corps, School-to Work Opportunities, and the Americorps community service project.

An emerging, new category of providers are those associated with the transition of adults from employer to employer, from career to career, or from career to workforce withdrawal. These include public and private outplacement organizations, career counselors, and testing professionals. Although some elements of this category have been around in marginal quantities for some time, the 1980s and 1990s have fostered these as growth industries brought about by the massive restructuring of the workplace as it retools from the Industrial Era to the Information Age, and as the marketplace has become more global.

While employers have recognized the need to provide educational and training opportunities, employer-provided training in United States tends to be chaotic. **Only recently have steps been taken to produce a generally accepted and structured approach to job definition, qualification, assessment, and advancement.** In contrast, Germany and France have extremely mature vocational systems which articulate job definition, skill requirements, training methods, and assessment strategies. The result is a system which produces extremely-well qualified and professional employees. However, these systems have also been criticized as being inflexible, which prevents the German and French economies from being able to react quickly to a fluid international market environment (possibly explaining their higher unemployment rates when compared to the U.S.).

Conduct

The largest portion of the conduct of U.S. education and training institutions concerned with transition issues has traditionally been left to the **public sector** in the **school-to-work** areas, and to the **private sector** in **outplacement** and **retraining** areas. The behavior of providers in these areas has been decentralized and locally-controlled, reflecting the control of local school boards and districts over secondary schooling and the dominance of competing small business providers in areas associated with workforce outplacement and retraining.

Accordingly, the role of the Federal Government in school-to-work efforts has been to set standards, to collect data, to sponsor research, and to fund incubation projects which serve national goals. The **School-to-Work Opportunities Act of 1994** is a good example. It established a system of developmental grants with which states are building local school-to-work educational systems and partnerships with local businesses. Such systems include technical education and preparation (tech-prep), cooperative educational efforts, career academies, and school-to-apprenticeship programs. Private businesses and even labor unions have provided paid apprenticeship opportunities, have helped design technical preparation school curricula, and have offered mentoring programs and grants for public school systems.

As for transitional outplacement and retraining, the restructuring of private industry and the downsizing of the Department of Defense spawned hundreds of significant contracts with outplacement service providers in the past decade or so, growing a cohort of providers who help displaced employees. These firms assist workers who are leaving to identify career alternatives, diagnose skill gaps, and obtain the training necessary to succeed in the future. Given the dynamics of the everchanging workplace, and the likelihood of future workers changing jobs multiple times in their careers, the number of retraining and outplacement providers is expected to continue to grow.

The conduct of various school-to-work education and training efforts is marked today by an increasing trend toward **computerization** and the use of **information databases**. In today's primary school systems, the ratio of computers to students is 1 in 15; in secondary systems, the ratio is 1 in 13. **Ninety-eight percent** of American schools, moreover, report computer usage. This level of computer usage is also reinvigorating stagnant vocational programs, driving them more in the direction of technical preparation educational programs. Computer usage also adds depth and credibility to technology education and training, assisting students' transition to the modern, automated workplace. The ratio of computers to students must improve, however, in order to meet the demands of the changing workplace.

Performance

The Transition Pillar as a whole is fairly new. Although public and proprietary education and training systems are some 200 years old, only recently have reinvigorated school-to-work and outplacement efforts crystallized and become such a focus of attention. This is especially true for the outplacement category of efforts, which has grown largely from a cottage industry of employment agencies to a national and multidisciplinary industry of counseling, testing, coaching, and employment preparation firms.

However, as recently as 1992 the U.S. Office of Technology Assessment rated

the performance of school-to-work transition efforts as **"left mostly to chance"** with few employers having ties to schools in the old vocational type of programs. The newer programs, infused with a concern for modern technology and workplace validity, are changing the assessments of some programs, as we noted in our visits with the State of Maryland Education Department and the Fairfax County, Virginia school system.

Finally, we turn to a consideration of four-year college degree programs. The American collegiate education system is widely viewed as being the most successful in the world. It is the beneficiary of not only public education funds, but also private endowments and governmental research and development grants. Recently, however, some have grown concerned about the quality of incoming students, who seem not to be sufficiently prepared in basic literacy and numeracy skills. This might even be associated with the fact that **more than 40 percent** of incoming college freshmen **drop out** of college before completion of a degree program.

It is interesting to compare the American transition pillar system with equivalent German and French organizations. France and Germany have been very successful in linking strongly structured school courses to a workmarket characterized in terms of precise job definitions and qualifications. In comparison, the American "system" appears much less coherent--both the workplace and the school seem to evolve under their own dynamics, with the task to fill the gap between the two being left to spotty and short-lived programs. The highly structured approach of the German "Dual System" or of the French "Enseignement Professionnel" may well translate into the rigidities that at least partially explain their higher unemployment levels. On the other hand, the **flexibility** of the American system can become a key element in the process to adjust to the everchanging requirements of the 21st century workplace. In fact, community colleges may lead the way!

The privately-owned Education and Testing Service in Princeton, New Jersey, has produced some evidence that today's high school graduates are essentially as literate in reading and math skills as past generations, so the perception of declining literacy is troublesome. Perhaps part of the answer lies in the more demanding work environments of modern time. Then too, static test-taking abilities within a given academic discipline may not translate into a workplace which is increasingly more dynamic and multidisciplinary.

Conclusion

- School systems are becoming more sophisticated in their curriculums as more businesses link arms with students. Still, we must continue to progress in the area of transition to the workplace as the U.S. seeks to remain competitive with the highly capable workforces of our international competitors, especially in Europe and Asia.

- The chief weakness of the effort today is its spottiness--the quality of school-to-work programs must be made uniformly excellent for all races and in all geographic regions, despite regional economic weaknesses. This will be especially challenging, given increasing economic inequities in the United States between the haves and have-nots, and in view of the growing diversity of the workforce.

- As for the outplacement and retraining segment of this pillar, private enterprise seems well-suited to meet the expectation of continuing demand. More emphasis should be placed, however, on the life-long learning needs of Americans. There will be more transitions between and outside of workplace environments in the 21st century.

- Better assessment mechanisms are needed for all transition pillar activities to inform the taxpayer of economies and efficiencies, and to alert program managers of crises and opportunities.

The "transition" pillar may be characterized by the distortion between ever-increasing requirements from a workplace strongly pulled toward the future by global competition, and by a school system that lacks a coherent and comprehensive process to adjust to this dynamic, global environment. This second pillar must face the difficult challenge to reduce this distortion in the midst of growing societal disparities and sparse financial resources.

WORKPLACE PILLAR

In this section, we will briefly examine the third structural component of education and training--the workplace pillar. This pillar includes the structure, conduct, and performance of education and training in the workplace. In examining the workplace, one quickly realizes it has become more global in nature, with competitiveness as the primary measure of success. The workplace, therefore, is being redefined from its roots as a place of local life-long employment to one where skills must be continually upgraded to remain competitive and employed.

To succeed in the future, employers have recognized the need for a highly qualified workforce. Employers are seeking job candidates with a foundation for workplace competency which includes not only the basic skills (reading, writing, arithmetic, etc.), but also thinking skills and positive personal qualities. Other productive skills sought by employers include the ability to allocate resources, communicate interpersonally, process information, apply systems, and understand technology. As a result, employers are demanding more from our schools while at the same time trying to educate and train the current workforce at a reasonable cost. The workplace pillar is where most Americans will spend the greatest part of their lives--what they learn during their workplace years will most directly affect their continuing ability to earn.

Structure

Education and training in the workplace may be formal or informal and usually involves every employee. Private and public corporations, including, the Department of Defense (DoD) comprise the bulk of the employers who provide for the formal and informal education and training of the workforce. Corporate spending for formal education and training amounted to $36 billion in 1994. DoD estimates it will spend over $14 billion for formal education and training during fiscal year 1995. Since informal training normally occurs while on the job, there is no generally accepted method for calculating its cost. However, the cost of informal training is generally considered to be significantly higher than the amount spent for formal training. As enterprises concentrate on becoming more competitive internationally, improved methods of providing both formal and informal education and training to the workforce at a reduced cost will become a primary driver.

Formal and informal employer-provided education and training exists within both public and private enterprises. Formal corporate training can be divided into three broad types of education and training--<u>professional development courses</u> (e.g., leadership and problem-solving courses); <u>skill-building courses</u> (e.g., writing, negotiating, and computer skill courses); and <u>seminars</u> (e.g., sessions on such topics as affirmative action laws, new production methods and procedures, etc.) Formal

training within DoD falls into six categories--(1) recruit training, (2) specialized skill training, (3) one-station unit training, (4) officer acquisition training, (5) flight training, and (6) professional development training.

Informal training is conducted in all organizations, and it comprises the bulk of education and training given to employees. Informal training generally involves teaching employees office procedures, the use of equipment and tools, or new production techniques. Consequently, the cost of providing such informal instruction becomes extremely elusive.

From a supplier standpoint, an analysis of available data indicates **a robust formal education and training industry is available to corporate America.** The volume of resources expended, the number of sellers competing, and the variety of products differentiated portray an extensive and highly competitive market for education and training services. However, commercially available education and training services attempt to appeal to the largest audience by targeting management and technical related instruction because this is the area of greatest expenditure on the part of enterprises.

From a consumer standpoint, the data also indicate public sector buyers exhibit different behaviors than do private sector buyers. Public sector buyers purchase more seminars and conferences rather than hands-on technical training. Also, public sector buyers prefer a different mix of products which emphasize more general management and administrative topics such as clerical training, dispute resolution, and health promotion activities.

Large corporations, on the other hand, are the primary source of formal job training. Of the money spent by corporations on training, managers and technicians receive the most with 66% spent on employees who already possess a college education. The literacy study published in 1992 indicated most job training was provided to those individuals who already had a high level of skills and were in literacy levels three through five. The remaining 34% was spent on those with the least formal education and training.

In recent years, technological innovation has fostered considerable change for those on the shop floor. Manufacturing processes related to production quality and cost have become the primary focus. The internationalization of production and markets has also intensified competition resulting in a flattening of the organization and a significant increase in the use of computer-related technology. Consequently, employers have found that a significant number of high school graduates need remedial work in grammar, mathematics, and basic problem-solving skills, before they are ready to take a job. Of approximately 13 million college students in 1989, more than 2 million were enrolled in remedial courses in reading, writing, or mathematics. **As a result, the competitiveness of U. S. workers at the entry level has declined**

compared with workers in some European and Pacific Rim countries. In response, American educational institutions are **exposing children to careers earlier in the process.** Secondary schools are **developing school-to-work paths** which demonstrate the practical application of learning. **Businesses are also developing partnerships with schools** in an effort to ensure that entry level applicants come ready to work without the need for remedial instruction. And finally, industrial and commercial leaders are **developing common job definitions, standards, and assessment programs to promote preparedness, mobility, and advancement.**

Also, a job today is no longer a commitment to life-long employment. Employees entering the workplace today **can expect to change jobs six or seven times in the course of their careers.** Employees once considered to have sufficient skills for lifetime employment find they must learn new knowledge and skills to sustain their employment in an environment increasingly driven by technology.

As competition increases and bottom lines become more important, **employers are becoming more reluctant to provide remedial educational services.** The increased availability of workers with significantly higher levels of education and training has caused a general increase in the basic mandatory knowledge, skills, and abilities associated with jobs in the workplace. Consequently, the gap in income between those with higher and lower levels of education continues to increase. In order to maintain their competitiveness, employees are being forced to constantly retrain and to operate in a mode of continuous life long learning.

In addition, the cost of education and training directly affects bottom line profits. Consequently, much of the education and training that is provided in the U.S. is "stove-piped" based on immediate requirements of the moment with no clear end-state in mind nor any relationship to long-term company goals or objectives. Quarterly profit statements have become America's yardstick of success. Perhaps as the U.S. rebounds economically, growth in corporate spending for education and training will rebound to the rates of the early 1990s.

Conduct

Formalized education and training programs within an industry are dependent upon the specific needs of the corporation. The workplace views formal education and training in the short run relative to a specific job or skill which needs to be performed versus the long term view of promoting the overall ability of the employee to contribute across the broad range of activities needed to improve the product or service provided. Exceptions include education and training mandated by legal requirements (i.e. sexual harassment, legal issues, etc.).

Technical production training dictated by business initiatives and the introduction of technology is still the primary thrust of corporate training facilities. Most

industrial training institutions view their role as improving the technical competency of an employee's current skills, vice improving the overall genesis of an employee which would enhance their overall flexibility while contributing to the long-term survivability of the company. This dichotomy between short- term profits and long-term survivability has put industry, in general, in a state of turmoil as to the objective and vehicles to be used to educate and train the workforce.

The **views** on education and training **between labor and management** are also in a state of flux. In the past, few unions have had a collaborative agreement with management which ensures **worker rights relative to continued education and training benefits**. This, at least on the surface, seems to be changing as labor begins to play a more participatory role in management. The exclusive domain of middle management in the past is now occupied by union employees who participate in running the operation through self-directed work teams, as well as developing the formal definition of job skills, training requirements, and assessment tools. They are no longer considered simply "labor" or raw material. Unions have also recognized the long-term requirements for ensuring their future viability by providing current contracts which ensure the provision of skills needed to successfully compete in the next millennium.

The **nature of the workplace continues to change dramatically** as technological innovation and continuous information flows create overwhelming and rapid changes in the resources, production processes, products, and services available today. The fluidity of the work environment make conventional forms of education and training irrelevant to today's position and tomorrow's direction. Information technology is changing at such a tremendous pace, as well as the amount and currency of information available, that the education and training industry is having to look at new roles and missions.

Corporations are examining a variety of methods to meet the increasing demand for education and training. Some are establishing their own form of university education to provide advanced learning in high-tech areas. These same services and facilities are offered to their suppliers, as well as the customers who utilize their products. This interactive process between a corporation, its suppliers, and its customers is becoming imperative to ensure a commitment to quality is infused into every aspect of the business.

In an attempt to reduce education and training costs, enterprises are pursuing alternative means of instructional delivery. One method currently experiencing some popularity is the concept of **distance learning**. Through the use of advanced digital and video technologies, up-to-date instruction can be provided to remote locations in both domestic and international markets. In addition, advances in two-way communication are allowing distance learning to become more interactive, which has been one of its main criticisms in the past. Consequently, its ability to provide current

information at a relatively low cost when compared to standard instructional methods which incur time delays, travel expenses, and the opportunity costs of lost production time are making it extremely attractive.

Other enterprises are seeking to reduce the high cost of training through **outsourcing**. Commercial enterprises for the preparation, delivery, and assessment of training is a growing market. Local community colleges are rising to the challenge by offering tailored courses of instruction at rates far below those of professional training organizations normally found in the marketplace. In addition, local community colleges are playing a key role in the retraining of the workforce as markets are lost and local workforces become displaced.

Businesses and institutions are **partnering with academic institutions** in an attempt to improve the quality of education as it is initially delivered rather than having to provide remedial services on the job. This partnership between school and work improves the understanding of students as to the importance of learning through application while establishing the linkage between learning and earning. Germany and France have proven the value of such a system of advanced apprenticeship programs. Britain has recently initiated a comprehensive program aimed at vocational training in cooperation with industry. Historically, both students and the partnering enterprises have gained from the experience.

A corporation must continually determine the best method of providing education and training by assessing the relevance of the delivery vehicle, its cost, and the competitive edge it delivers, when reviewing all of the training options available today. The overall objective has become the provision of the best education and training available in near real-time at the least cost.

Performance

The evaluation of training performance in the workplace is a complex process and an inexact science at best. The range of training encompasses everything from informal on-the-job training to formal structured classroom instruction. In the last five years, formal corporate training expenditures have increased by about 6 percent per year to an estimated $36 billion in 1994. Although there is no generally accepted method of calculating the cost of informal workplace training, most agree that it is significantly higher than the amount of formal training.

Formal training in the United States is largely limited to supervisors, managers, and technicians, accounting for nearly two-thirds of expenditures. This contrasts with Britain, Germany and Japan which focus their resources at the entry level. Once a field of employment is chosen, definitive qualifications for entry as well as for promotion and advancement are available. Formal mechanisms of education and training are readily available and paid for by the state.

In the U.S., the methods and results vary with **pockets of excellence**. Some companies like Xerox and Motorola have recognized the value of education and training. In response, they have developed formal broad-based training programs which leverage technology to their advantage. Most other companies lack the vision and structure needed to invest in education and training with a commitment to the long term. As a result, training is often chaotic and focused on short-term costs and benefits. The cost of education and training becomes critical only as an expense on the quarterly profit and loss statement. Long-term vision and policy have become secondary to political considerations and short-term costs.

While industry has led education and training in the workplace pillar, the role of the Federal Government has been erratic at best. There is no single agency which coordinates a broad based education and training policy for our schools, the transition to work, or in the workplace itself. As a result, there are many stovepipe federal programs which either target very specific segments of our population or are mandated because of previous litigation. In targeting specific groups, federal agencies set up stringent participation requirements and mandated excessive oversight responsibilities. Consequently, the federal role in achieving a higher national level of education and training has been chaotic, resulting in state and local governments assuming more and more of a leadership role within their regions.

State government aid to employers has increased. There is evidence that these state subsidies have increased the amount of formal training provided to employees--ultimately increasing productivity. In a study of 155 manufacturing firms who introduced formal training programs, Michigan researchers found a productivity growth rate 19 percent greater on average than firms who did not offer formal training. Because of the positive results achieved, the amount of state aid provided to employers to support training is growing.

Arguably, **some of the best results come from training in general education--courses in basic reading, writing, and math improvement, often through onsite partnerships with community colleges and universities**. Although some companies fear the resulting better-educated employees will use their enhanced skills to jump to better paying jobs with other companies, the more enlightened firms are using this life-long learning as an opportunity which directly benefits their enterprise. They continue to employ the more skilled workers in other positions within the firm to capitalize better on their higher skill levels.

Corporations have also found that the returns on general education are higher than those of specialized training because the education is transferable; whereas, specialized training tends to be more limited by the specifics of the job. In fact, the most successful training is that which focuses on the long-term sustainable development of the employee rather than that which is short-term in nature and driven by bottom-line cost considerations.

Conclusion

Overall, the major findings of the Workplace Pillar in support of our overall education and training system are:

- The workplace, driven by increased international competitiveness, is generating increased educational requirements and a need for improved skill levels.

- In response, enterprises are asking more of our academic institutions while struggling to provide quality training at a low cost to the existing workforce.

- Employer provided training in the U.S. is chaotic--focusing on short-term needs and costs versus long-term benefits and organizational survivability.

- Federal support to education and training has been erratic and affects only a small percentage of the population. State funding has had more success in stimulating productivity gains through education and training.

- Although France and Germany have more mature systems to advance vocational training, they have been criticized as being inflexible when dealing with the fluid international market.

- The best results from training are achieved in general education courses which are transferable and have broader applicability.

- Human capital is becoming recognized as our greatest national resource. Efforts are now underway within the U.S. to tie learning to earning by creating an environment for life- long learning.

STRATEGIC ASSESSMENT

This section addresses the trends, issues, and challenges noted by our industry study team thereby setting the stage for our proposed education strategy for the year 2020.

<u>Major Trends in Education and Training</u>: With this background in mind, our team observed several major trends in the education and training industry during the course of our study:

- An increased focus on ***empowering the <u>key</u> stakeholders*** of the educational process ***at the local level*** and holding them accountable for the results (key players here are students, teachers, parents, and school principals). Strong leadership by the principal and his or her staff, while not the exclusive factor, was witnessed as a consistently central element in school and student successes.

- The development of ***common curricula and standards*** as a core point of departure for ***integrated coursework*** delivered in a team learning environment. One of the principal focuses here is on learning how to learn, not merely memorizing facts (i.e., continuous self-improvement through the development of life-long learning habits).

- Continued ***refinement of assessment techniques*** to measure more precisely the performance of students and the educational system overall. The more notable areas were revisions to the Scholastic Aptitude Test (to focus more on contextual learning versus memorization) and use of the National Assessment of Educational Progress (NAEP) as a broader, more accurate measure of student achievement. The challenge is to design a test measuring outcomes such that those outcomes can be influenced, and thus become the standard of achievement.

-Increasing emphasis on the use of ***computers and learning technologies*** to assist teachers and instructors with delivering course material in a self-paced manner to meet varied learning needs.

-***Improving the linkages between schools and businesses*** recognizing the importance of the school in preparing the future workforce. Businesses have long complained that high school graduates lack the skills needed to succeed in the workplace. (The top workplace skills deficiencies are reading, writing, speaking, problem solving, and responsible work habits.) School-to-work programs expose students early-on to career options and provide work experiences to help them make more informed career choices. Work standards by industry, combined with teaching the attributes of teamwork, creativity, flexibility, communication skills, and continuous improvement, are all designed to reduce remediation by employers while preparing students for work in the "real world."

- ***Classrooms, as a microcosm of society*** are becoming increasingly diverse with the shifting demographics (birth rates and immigration trends) of the U.S. This creates demands for specialized instruction (English as a second language) and curriculum changes in history and the social sciences to accommodate these growing cultural segments of our society.

- Societal tensions (drugs, crime, teenage pregnancies, homelessness, broken homes, and single or no parent families) and unsafe schools distract children from being ready to learn. ***Schools are thrust into more social welfare roles*** diverting time, energy, and resources from the core role of teaching the curriculum.

- Last, but not least, ***budget pressures*** at Federal, State, and local levels will put school systems in an ever-tightening squeeze, requiring even more creativity and greater cooperation among educators, local officials, and business leaders. Budget deficits generated largely in the 1980s and 1990s have produced political pressures

for balanced budgets at all levels of government. This will translate into resource scarcity for those interested in increasing funds for education and training, or in updating supplies and technological platforms. This budget tension adds to the present inequities based on funding schools primarily through property taxes (richer communities have a larger tax base and can offer more resources per capita compared to poorer communities). During this same period, businesses have tended to underplay their role in training, from both a traditional lack of strategic interest in long-term issues, and by a scarcity of resources.

Major Issues in Education and Training: The following section lists the major issues identified during our course of study:

- ***Parental Involvement***: The family structure has been in a state of transition for some time. Two parent families are decreasing as a percentage of total families, a result of societal and economic pressures. Never before has there been less adult supervision in our homes, yet parental involvement is a critical ingredient in a child's academic success. Parents are the first and most crucial teachers in a child's life--research indicates that quality nurturing during a child's early years becomes the building blocks for future academic achievement. The poor and disadvantaged face the greatest risk of not having enough quality interaction with their parents. Special programs, like Head Start, are used to counter this imbalance and help children start school ready to learn. Once a child moves into a formal educational environment, the parent should become a partner with the teacher in the learning process, assisting with the child's studies and providing feedback to the student, teacher, and school. Unfortunately, societal and economic trends will lean to less, not more parental involvement unless the parents make their child's education the number one priority for their disposable free time. Even the top schools show low (less than 10-15 percent) overall parental participation.

- ***Educational bureaucracy***: Often the structures of state and local educational systems lose sight of their main purpose--to educate and prepare our youth. These systems (often unwittingly) inhibit teamwork, teacher participation, and continuous improvement initiatives. For example, teachers need to be involved in curriculum development, establishment of school policies, and appraisal of instructional methods--often, the teachers are left out of these processes. School principals fare no better in the present system--instead of acting as Chief Operating Officer of their school, many principals are "handcuffed" by school board control over financial resources, employment decisions, and policy initiatives. While noting the emerging empowerment trend for the schools we visited, we were nevertheless left with the impression that the education industry overall has been slow to fully embrace the concepts of total quality management.

- ***School funding***: Public schools are largely funded at the state and local level, with local funding coming primarily from property tax proceeds. Local funding

inequities occur in two broad instances: first, more affluent neighborhoods are able to contribute more per capita than poorer sections; and second, aging communities (high number of families with no children at home) pay property tax with no apparent, tangible benefit. Two other factors compound the funding "equity" issue: school choice and voucher portability, and the diversion of lottery proceeds (originally sold as education revenue sources) to other state needs.

- ***School calendar***: The structure of the school calendar is based upon the agrarian model used 100 years ago to meet the crop harvesting needs of a bustling farm economy. The three-month summer break is an inefficient use of both the physical plant and the students mental capital (the first few weeks of each new school year is spent "reviewing" material and "reengaging" mental capacities). The length of the school day is still seven hours, punctuated by recesses and a lunch period. External demands drive "other instruction" up, leaving less than five hours for core instruction a day. Besides the school day not being long enough to meet instructional needs, many students are "latch key" kids after school (see parental involvement above).

- ***School safety***: Schools are no longer a shelter from the violence and ills of society--in fact, these ills are often brought into schools from the outside. Every day newspapers report assorted crimes committed within the confines of our schools, from the high schools of the inner city to the grade schools in suburbia and every school type in between. The school must provide students a safe haven--it's tough to concentrate on coursework when one fears for his or her safety. Teachers and administrators are saddled with the unwanted, added mission of ensuring student safety and of accommodating for the fact that many students will be direct or indirect victims of crime

- ***Teacher recruitment and training***: The quality of the teaching profession is an important influence on the health and future of our educational system. The current population of teachers is comprised of a large segment rapidly approaching retirement age; the void left by these retirements is going to be very difficult to fill. Low salaries, overcrowded classrooms, safety concerns, and a bureaucracy that stifles initiative act as roadblocks to effective recruitment of new teachers. The number of students who enter college with a stated desire to become teachers has dramatically declined, so new sources for the teacher profession must be found. Once they are on board, every teacher should undergo continuing education and recertification to maintain their currency and relevance in the classroom. Like any profession, teachers need to stay current in their field, and staff development is crucial to the health of the profession and the institution it serves.

- ***Student Assessment***: The way in which we assess our students has changed very little from the assessment practices of decades ago. Examinations focus on the student's ability to memorize and regurgitate information on short answer,

fill-in-the- blank or multiple-choice questions. Tests such as these are easy to develop and easy to grade, but fail to challenge the critical thinking of the student. Instead, assessment tools should measure a student's intellectual ability to assimilate information, integrate knowledge, and articulate a response.

- ***Technology in the schools***: Growing technical expertise will be a continuing demand on into the 21st Century. A significant counterweight to this will be the drag of waiting for school systems to uniformly adopt, employ, integrate, and upgrade technological systems in a manner which keeps up with those same systems as they are upgraded and employed in the workplace. We need strategies which will allow virtually seamless transitions from education and training technology to industrial and informational technology. Computers are being used more and more to help out in the classroom, yet there is concern that technology is viewed not as a tool, but an end to itself. The rapid advances in technology result in rapid obsolescence, adding to the frustration of the users in their drive to "stay current." And over-reliance on computers as a teaching tool encourages individual-oriented learning behaviors, the antithesis of team problem solving and participative interaction skills demanded by employers.

- ***Growing Diversity***: The demographic growth in both native and immigrant minority group populations is likely to exert more stress on both education and training systems; this will be no less true for those programs associated with the Transition Pillar. The challenge, according to Senator William Bradley of New Jersey, is that by the year 2000 only 57 percent of the people entering the work force in America will be native born whites. That means the economic future of the children of white Americans will increasingly depend on the talents of non-white Americans. If we allow them to fail because of our penny pinching or timidity about straight talk, America will become a second-rate power. Even more, we should not be looking at minority students only in terms of potential failure and troublesome remediation, but more in terms of potential **resource** and latent **creativity**, so that our society can profit from **diversity**.

- ***Increased Special Education Requirements***: Because of social and economic disadvantages, minority groups generally produce more youth with special education needs than do white citizen cohorts. As the demography of the nation becomes more diverse, special education requirements are expected to claim more educational resources and to require more specially-trained teachers and trainers. However, this claim will not be limited to minority groups, but will probably affect also the growing cohort of poorer white Americans that increasingly drop out of the traditional middle-class.

- ***Federal role in education***: Our nation has a long history of decentralized execution of education at the state and local level. Nevertheless, amidst recurring cries for national standards, assessment criteria, and overall uniformity in our education system, comes a call for increased federal involvement. Almost every

organization we visited felt the Federal Government should provide the overall vision, articulate the goals, develop the priorities, coordinate the strategies, leverage funding, facilitate standards and certification, collect, index and disseminate integrated information, and promulgate learning assessments and lessons learned among all educational stakeholders. Execution of the educational mission should be left to state and local officials.

EDUCATION STRATEGY FOR THE YEAR 2020

Education is the *sine qua non* for a healthy, productive, functioning society, and it is the foundational element for national security. The education system must prepare our citizens to cope, adjust, adapt, and succeed in the ever-changing world we live in. Given the importance of education to the nation's well-being and economic prosperity of its citizens, the Education and Training Industry Study recommends the following objectives and goals to meet the national security needs through 2020. Where appropriate, specific strategies and policies are also proposed.

- *Empowering local officials (principals, staff) with execution of the school pillar mission, providing them control over the resources they receive and holding them accountable for the results.*

- *Reengineer our schools. Move to a revised calendar (for both year-round schooling and lengthened daily schedules) in recognition of the changed needs of society. (For the most part, the school systems that piloted year-round and lengthened-day schooling have overcome the initial objections and are faring quite well in their full-up implementation.) Integrate government and non-government social agencies in schools (one stop service for parents and kids). Free teachers to teach scholastic material and act as a "team facilitator" to direct people to available resources.*

- *Reinvigorate teaching as an honorable profession. Improve recruitment, increase compensation, and stress continuing staff development and recertification to raise and maintain standards of the profession. Start with the teaching colleges and institutions and move throughout the industry. Incentivize retiring military and federal civilian workers to pursue teaching as a second profession.*

- *Recognize that it takes "a whole village to raise a child." Foster social partnerships in the local community between educators, businesses, and local governments in support of their educational mission. Parental involvement is a critical aspect of this partnership and underpins the entire educational mission.*

- *Increase the emphasis on school-to-work relationships and increase opportunities for vocational/technical training. Place emphasis on standards and certifications, as identified by business, to define the work-oriented learning outcomes*

desired. Embrace the British educational concept of "parity of esteem" to instill the attitude that every educational path (scholastic, vocational, or job-specific training) adds value to society. Increase reliance on community colleges as a centerpiece element for both the Transition and Workplace pillars--community colleges can become a significant enabler of a "life-long learning environment" for a large proportion of the American public.

- Foster the use of technology in the classroom as a means to facilitate teaching a student population with diverse abilities, with the secondary mission of introducing technology as a future workplace tool.

- From an early age, foster the attitude of "life-long learning" within every element of the American educational framework, instilling and reinforcing the philosophy that "learning is a continuous journey" for all American citizens.

- Set high expectations in every aspect of the educational mission, from curriculum to assessment techniques, from teacher performance to student performance, from school administration to parental involvement.

SUMMARY AND CONCLUSION

The world has changed, and it continues to evolve dramatically. World economies are more interdependent, and the global information explosion has rewritten the rules for human interaction at all levels--from individuals to industrial and political centers of power. The information explosion creates and turns over new knowledge every 18 months, challenging cycle times and capacities of humans, markets, and governments. Free market economies and emerging democracies are springing up all over the world, adding to the opportunities for growth, competition, and instability.

Our education systems must be able to cope amidst the backdrop of this "permanent white water" environment. These systems must prepare people for the challenges of the 21st century by: providing a solid academic foundation; offering a variety of alternative educational pathways to productive employment and scholarship; providing those foundational skills essential to the workplace and effective functioning in society; and continuing to provide a network of educational opportunities available to all as life circumstances change.

Adam Smith said "the wealth of a nation lies in its people." Our nation's economic power is the engine for national security, and the skills, knowledge, and flexibility of our workforce will fuel the economic engine and secure our collective future. The most effective way to leverage that wealth is through continuous and never-ending education--life-long learning. Central to this philosophy is ensuring our citizens are taught "how to learn" so they have the most fundamental skill necessary

to survive and succeed in a dynamic world.

INDUSTRY STUDY

#8

ELECTRONICS

TABLE OF CONTENTS

PARTICIPANTS

Students

LTC Mario Cervantes, USA

LTC Dave Chaffee, USAF

COL Herman Loidolt, Austrian Army

LTC Steve Mills, USA

Ms. Esther Morse, D/A

LTC Sam Norman, USAF

LTC Dave Neyland, USAF

COL Prodromos Spahidis, Hellenic Army

CAPT Hugh Story, USN

Mr. Kevin Tansey, General Accounting Office

LTC Larry Troffer, USMC

Mr. Pat Warfle, Central Imaging Office

Faculty

Dr. Don Losman

Dr. Ken Moss

PLACES VISITED

Domestic

Naval Research Laboratory
Virginia Semiconductor
S.T. Research
Westinghouse
Loral
Raytheon
Oracle

International Travel

Singapore Electronics & Eng
National Semiconductor (Singapore)
Compaq, Singapore
Siemens, Singapore
Motorola, Malaysia
Texas Instruments, Malaysia
Airod, Malaysia
Institute of National Strategic Studies, Malaysia
497 CTS

GUEST SPEAKERS

Electronics Industry Assoc.
Defense Electronics Supply Center
Singapore Ministry of Defense
Malaysia Defense Ministry
Foreign Ministers of Singapore and Malaysia
State Department
U.S. Embassy Teams Briefings
COMLOG WESTPAC
Electronics Systems Center (Hanscom AFB)

INTRODUCTION

With the study of electronics comes the realization of how pervasive electronics is in our lives. From the guidance system of *smart* bombs that helped swift victory in Desert Shield/Storm to the chip that regulates highways traffic lights, electronic components are there. From the sophisticated circuitry that enables surgeons to repair damaged retinas of the human eye . . . to the simple digital watch that helped that surgeon awaken on schedule, electronics are there. Electronics products are also critical to national defense. Our military strategy has for years professed a reliance on high technology to enable our relatively smaller forces to defeat a numerically superior force. Virtually every high-tech weapon system in the inventory relies on electronics--primarily solid-state semiconductors and computers. Electronic systems enable our warriors to see at night, to track targets from afar, to guide missiles, and to control jet engines and shipboard propulsion plants. They work in extremes of hot, cold, wet, and dry weather. They have proven their worth in combat. This ubiquitous nature of electronics has made the task of writing about the industry a matter of selecting the most salient topics and presenting an overview of the rest of the industry. Our study was drawn from basic library research, guest speakers representing the industry, trade associations, government regulators, and from the business and foreign government contacts associated with our domestic and international travel.

SEMICONDUCTORS

Miniaturization has become the order of the day! The silicon atom measures 4 angstroms in diameter. Typical transistors today measure about 300-400 angstroms in width. An entire gate-array measures 0.35 micrometers and is used as the "standard measure" for integrated circuit *state of the art* components. For comparison, a human hair measures approximately 100 micrometers in width. This depiction of semiconductor dimensions highlights the detail and complexity of the semiconductor business. The semiconductor story is an interesting one, defining the very essence of electronics in today's information age. Even Chevrolet, which proclaims itself as the "Heartbeat of America", runs on electronics. It is vital to understand semiconductors, which are central to modern electronics. For this report we review the basic structure of the semiconductor sector, discuss its performance, and provide future performance projections.

Structure of the United States Semiconductor Industry

The semiconductor industry is divided into three types of manufacturers: (1)Large, vertically integrated electronics firms, known by most as *integrated merchants,* who produce semiconductors and use them as inputs for their own electronic products, or sell to others; (2)independent firms that manufacture solely for outside sale, whom we call *pure-play* merchants; and, (3)semiconductor producers operating within large, vertically integrated electronics firms, known as *captives.* In the

past, all data was gathered as *captive* versus *merchant*, but there are those who feel that *captive* companies, more and more, will come into the *integrated merchant* category where they will produce chips for their parent companies as well as for the market. It is difficult to measure the sales and market supplied by present *captive* semiconductor firms. Accordingly, measures of the state of the industry will be mainly in terms of the *merchant* manufacturers.

This shift in structure may be more than coincidence. The early success in semiconductors was very much carried out by splinter companies (from larger businesses) that later failed to react to market "callings" and technical possibilities. The current transition to integrated merchant semiconductor firms may be great news since the American competitive strength tends to lie in design innovation normally carried out most successfully by smaller groups.

Another structural characteristic of this sector is the truly global nature of manufacturing. Are IBM, Texas Instruments and Intel American corporations or are they global? Semiconductors, as is true of the rest of the electronics industry, are no longer tied to a single country. According to the Semiconductor Industry Association (SIA), the majority of research and development (R&D), wafer fabrication, and related corporate overhead functions are located at a firm's geographic base of origin. The phrase "base of origin" is, in itself, indicative of the loss of country identity for many of these firms. Also, to serve foreign markets and to reduce costs, companies move some manufacturing offshore. Some argue that this costs America jobs. However, a look at a few personnel statistics brings another perspective. Approximately 50% of U.S. merchant semiconductor employees are based in North America. And while worldwide employment levels in semiconductors have come full circle since 1978, of the 220,000 employees worldwide, there has been a gradual long term increase in the share of employees based in North America. Finally, the labor cost differential is shrinking. Since 1980, the average cost of North American labor cost rose at an annual rate of only 10% while offshore labor rates increased an average of 13%. Narrowing this cost differential may well return more of the U.S. industry's operations to America. A chart published by the SIA shows this trend clearly over the last three years[1] (see Figure 1).

Performance

A view of semiconductor sales in the merchant market reveals substantial industry growth in raw dollar terms since 1982. ROW represents "rest of world" in this view[2] (see Figure 2). Published data through 1993 show a clear trend. Today U.S. semiconductor production surpasses Japan. Indeed, we may conclude that the merchant industry is "booming" for U.S. companies. It also shows an increasing rate of growth in ROW areas. Aggregate total (Figure 2) is approximately $80 billion; this amount shows the strength of merchant sales worldwide and gives some insight into the monetary significance of the industry.

Semiconductor Merchant Sales Worldwide

(See Figures 2 - 5). At $80 billion in sales in 1993, the trend continues upward. On the average, worldwide revenues double every five years, with an average annual growth rate of 15%. A review of other indicators tracked by the Department of Commerce and the Semiconductor Industry Association clearly shows growing strength in semiconductors worldwide and in the United States. This was not always the case. A brief history lesson is depicted in Figure 3. A look at the historical percent-change in U.S. merchant revenues reveals several silicon cycles. Perhaps the best known lapse was in 1984-86 when the Japanese allegedly "made their move" to intentionally undermine U.S. market share. But, the silicon cycle may be broken; trends since 1986 indicate continuing positive revenues. Although not shown, Commerce reports a 22% revenue gain in 1994, a bit down from 31% in 1993. This does not appear to be an immediate concern to U.S. merchants. All indicators are that the industry is strong today and enjoying an expanding world market.

World Market Share

Published data is classified into four general market regions: United States, Japan, Europe, and ROW, which includes other parts of Asia that are becoming important producers. For example, the Koreans have launched what is being called a "silicon duel" against the Japanese.[3] Figure 4 shows that by 1993 the ROW approximated Europe in both production and consumption.[4]

Prior to 1991, most observers were very pessimistic about the U.S. semiconductor industry. It is only in the last three years that the mood has turned positive. Several event shaped that change. First, the weak Japanese economy has hurt its own semiconductor business as ours did in the early 1980's. Added to that, the Japanese seem to have over-capitalized. There have also been pressures on Japan to increase imports, the strong Yen being one such inducement. By the end of the fourth quarter 1994, the foreign share of semiconductors in Japan itself had reached 23.2%![5] Even prior to that, the U.S. world market share caught up to the Japanese in 1993 at 41.6% and has since surpassed it.[6] U.S. share in the world market is summarized by the SIA through 1993 in Figure 5.[7] Tentative 1994 data show the U.S. holding approximately 43% of the world market. This data reflects only merchant sales, but this is the market that the captives will begin to enter if projections are correct that vertical producers will spread.

Research and Development and Capital Expenditures

Probably the most often touted messages of semiconductor producers are that R&D is critical and capital expenditures are exorbitant. In the mid 1980s, the U.S. Government assisted industry in the SEMATECH venture to improve U.S.

manufacturing's position in semiconductors and semiconductor manufacturing equipment. Now the industry no longer wants that government subsidy.[8] It is spending an average of 25% of revenues on capital equipment and R&D, with R&D alone consuming approximately 12% of revenues. In 1993, only the software and services sectors of American industry had higher figures on R&D.[9] While more recent trends are down, semiconductor businesses continue to sustain a strong R&D base since the "scare" of the mid 1980s (see Figure 6). The *Achilles' heel* in the R&D sector is basic research. SIA, in conjunction with virtually all players in the semiconductor business including government representation, has built a "National Technology Roadmap for Semiconductors." Published in 1994, this document is to serve as a guide for research and development to ensure industry is well apprised of the challenges ahead. In that report, the basic conclusion is this "gap" should be filled by the national semiconductor R&D community *in conjunction with federal and national laboratories*.[10] Overall indications are that the semiconductor industry is satisfied with its investment in R&D, but concerned that it will be overtaken by foreign competitors in years to come. The roadmap is being developed to create a cultural attitude of "urgency without crisis."[11]

The other major concern is the cost of capital equipment. A facility in Manassas, VA cost about $400 million in 1986. A comparable size facility with today's requirements would run closer to $1 billion. Other estimates of new chip factories run as high as $2 billion. Obviously, the cost to break into or even stay in this business is extreme. This explains the trend toward joint ventures and pre-competitive research in manufacturing. Factories are only "leading edge" for 2-3 years, so capital turnover is also high. The U.S. sector has now shown two peaks in capitalization as shown in Figure 7.[12] As we found in the 1980s and the Japanese are finding now, strength of the economy and currency have a great deal to do with performance in this industry. Fortunately, the new capital investment of our merchants coincides with a relatively strong economy and a competitive dollar.

Future Performance

Global semiconductor sales reached the $110 billion mark in 1994 and the industry expects to break $200 billion by the year 2000.[13] Overall annual growth is expected to stabilize at 10% without the industry volatility of the past. But individual "prophets" see a brighter future. Texas Instruments" . . . expects the world semiconductor market to grow by 21 percent" in 1995, to $124 billion.[14] They further project that the U.S. will individually see a 22% growth, Japan a modest 17%, Europe 23%, and the Asia-Pacific region a 26% growth. Business is booming. Of course, the drivers of such growth are computers, high density TV, and other commercial electronics end products that appear to be proliferating at increased rates. Stagnant economies could easily dispel such growth projections and throw the industry into turmoil.

One of the characteristics of the industry is its rate of technology turnover. It is worth looking at the Semiconductor Roadmap technology projection on where we may be headed; (see Figure 8). Although such projections are derived more from extrapolation of existing trends than from more rigorous analysis of technology patterns, a 0.10 micrometer feature production has been demonstrated and consortiums are being formed to attack the technology to achieve the above stated projections.

Defense Considerations

The defense sector is clearly becoming dependent on this commercial market. Yet, defense industry demand is less than 2% of the semiconductor market and can hardly be a significant influence. DoD has historically been a driver of transistor-transistor, bipolar construction, but sales in this area are declining at a rate of 8% per year. CMOS integrated circuits constitute more than 75% of the world semiconductor market today.[15] The Defense Technology Plan acknowledges the need to continue miniaturization in this technology area, reporting that "Military utilization of devices and circuits with feature sizes of .5 micrometer and below will enable order of magnitude advances in sensors, information, and electronic warfare signal processing systems. Low power, radiation-tolerant microelectronics are critical for military and commercial satellites."[16] Unfortunately, there remain only two U.S. manufacturers of radiation-tolerant chips. Therefore, DoD must continue to monitor this industry with care to ensure specific, unique requirements are addressed while maximizing use of commercial semiconductor capability.

Policy Considerations

As noted, one of the most famous government policy actions in the semiconductor sector is SEMATECH. Its company members claim it has been a success, but have differing interpretations on why it succeeded. A combination of rapid technology turnover, strength of economies and currencies, demand for consumer electronics "luxuries", and steeply downward sloping price curves all combine to form a confusing picture for ascertaining the success of this government sponsored program. There is little doubt that similar joint ventures and coalitions will be required for pre-competitive development ventures, particularly in the manufacturing development realm where capital investment is costly. But the exact contribution (aside from funding) of government is unclear. Industry has accepted this challenge with groups such as the SIA and the Semiconductor Research Corporation (SRC). Just recently, IBM, Loral, Motorola, and AT&T linked up to develop capable X-ray lithography for details below the 0.18 micrometer level.[17] Many other coalitions and joint arrangement are documented.

Much of the "industry" mentions the need for government intervention similar to the semiconductor agreement with Japan. SIA credits this agreement with the growth

in market share in Japan from less than 10% in the 1980s to greater than 21% for foreign suppliers in 1993. But again, the influence of this policy is controversial. Many factors have combined to make this change in the Japanese market, including some errors in their investments in semiconductors. The agreement may have helped the semiconductor industry in the U.S. to some degree, but it also hurt the end-item electronics sectors by increasing prices, thus harming consumers and export efforts. In 1991, the government again negotiated a follow-up semiconductor agreement with Japan.[18]

COMPUTERS

Advances in computer technology have been spectacular. Since the late 1950s, the price of entry-level computers has decreased by a factor of over 1,000 and for the fastest computer available, performance has reportedly increased by at least a million times.[19] The U.S. computer equipment market grew 19% in 1993, and an estimated 12% and 9% in 1994 and 1995, respectively, according to Department of Commerce officials. These officials expect growth to continue after 1995, but at a slower rate.[20]

Structure

The computer equipment industry can be divided into two overall categories. The first is electronic computers, which includes digital computers of all sizes (see Figure 9). The second category is computer peripheral equipment, which includes storage devices such as magnetic and optical disk drives and tape storage units, printers, graphic displays, computer terminals, etc.[21] Figure 10 depicts the overall computer industry's structure in terms of the flow of products and Figure 11 shows this industry's relationship to other industries.[22]

Location of the computer equipment industry in the United States is clustered in eight states: California, Massachusetts, Texas, Minnesota, Pennsylvania, New York, Washington, and Oregon, mostly near major universities. This enables the companies to benefit from the technical talent in and around these institutions.[23]

At the end of 1993, the United States led the world in the number of computers in use with 74.2 million, six times more than Japan, which had 12.2 million. Next were Germany (10.4 million), the United Kingdom (9.4 million), France (7.4 million), Canada (5.2 million), and Italy (4.4 million). These seven countries accounted for over 70% of the world's 173 million computers.[24]

Performance

The computer equipment industry is, in general, highly competitive and international. According to an unpublished Department of Commerce summary of the

prospects for world trade in computer equipment:[25]

"Continuously declining computer prices, steadily rising performance, and increasingly sophisticated uses have all stimulated domestic sales and exports. Yet the ever-accelerating tempo of technical change and product introductions has raised the costs and complexity of research and product development. The industry's operations have become more global . . . ."[26]

In 1994, the U.S. computer equipment industry concluded its third straight year of recovery from the 1990-1991 recession.[27] Starting from a recession low point of $49.1 billion (1991) in the value of U.S. product shipments,[28] the Bureau of the Census has reported annual growth rates of about 6%, 8%, 7% and 5% for 1992 through 1995, respectively.[29] The Bureau's estimated value of product shipments in 1995 is $63.3 billion[30] (see Figure 13).

Due to fierce price competition across a broad range of computer equipment products and reduced demand for some products, U.S. computer manufactures have been forced to streamline their operations and cut jobs.[31] The Bureau of the Census report shows decreases each year, 1990 through 1995, in both total employment and the number of production workers in the computer equipment industry.[32] Productivity increases have made this possible. See Figure 14 for details. Personal computers and workstations have become highly sensitive to price and technological factors, while suppliers of small computer systems have shortened their product life-cycles from several years to as little as nine months.[33]

U.S. Exports and Imports

U.S. suppliers, including their foreign affiliates, dominate world sales. Their market share grew to more than 75% of the $118 billion market in 1993. The U.S. position is especially strong in Canada and Europe, but weak in Japan.[34] Besides strengths in research, design, software development, marketing, and customer support, there are some additional factors that help preserve the U.S. computer equipment suppliers' lead. These are favorable exchange rates, especially versus the Japanese yen, and improvements in protecting U.S. intellectual property rights in important foreign markets.

Commerce officials maintain that this U.S. industry has a trade deficit because of its global source strategies. These officials explain that U.S. import growth is primarily the result of U.S. companies' deciding, based on technological and cost considerations, to source their production in various Asian countries by either setting up the company's own operations there or reaching production agreements with Asian firms. Parts and peripherals originating in Asia account for more than 80% of the value of all U.S. computer equipment imports.[35] The U.S. world export market share

for computer equipment dropped slightly during the early 1990s, and a traditionally strong U.S. trade surplus turned into a deficit. Imports rose almost three times faster than exports, which grew at a moderate rate of 5.8% annually from 1889 to 1993. Commerce officials estimate that for computer equipment: (1) U.S. imports grew by 21% in 1994, (2) imports (including those from American owned overseas suppliers) now constitute almost 60% of the value of U.S. purchases, (3) this sector had a trade deficit (which began in 1992) of $12 billion in 1994.[36]

Japanese companies are the strongest challengers and are especially strong in peripherals. But the domestic and export sales of most leading Japanese computer equipment suppliers declined in 1993. Moreover, their profit margins have declined as price competition has intensified. The Japanese companies were too slow in understanding the international market's shift from mainframes to smaller computer systems.[37] And the strong Yen has depressed exports.

Western European companies' technology is not competitive with either that of U.S. or Japanese firms. As a result, the European firms are losing money. To recover, the major firms have adopted the strategy of forming alliances with U.S. and Japanese companies.[38]

Many foreign governments (1) have restrictive trade and investment policies that limit imports and, consequently, adversely affect U.S. exports; (2) nurture domestic computer industries through such measures as support for R&D, "buy national" procurement policies, low interest financing, export subsidies, and tied aid; and (3) protect local suppliers and force the transfer of technology through tariff and non-tariff import barriers. Policies like these are often highly counterproductive. They frequently distort trade by limiting competition and slowing innovation. Those who buy products of local suppliers in these countries tend to pay more and get less (outdated technologies).[39]

Since 1990, U.S. firms have made an average annual investment in overseas operations of more than $21 billion; the desire to avoid tariff and non-tariff barriers in many countries has been a significant factor in such decisions. A lot of this money went to Western Europe, due to the growing importance of that market; but investments in Asia have also increased, as suppliers set up manufacturing operations to serve expanding markets in China and South Korea, and to take advantage of low labor rates[40] (and host country inducements).

Opportunities and Trends

It has been widely predicted that, during the next 5 to 10 years, a major new market will emerge-one called "infotainment." This potential market would provide personal access to a wide variety of entertainment and interactive information services, the synergistic effect of integrating computer, communications, and

consumer electronics technologies. Various combinations of computer, telephone, cable television, consumer electronics, entertainment, and publishing companies have merged or formed alliances, or are seeking to do so, to exploit this potential market. One significant challenge likely to face U.S. computer companies, especially if a giant infotainment market materializes, is even more intense competition against a broader range of domestic as well as foreign firms.[41]

U.S. computer firms' future survival is likely to depend on several key factors, including their ability to: (1) continually innovate; (2) attract and retain a highly skilled and educated work force; (3) quickly commercialize technological advances into marketable products; (4) sustain adequate levels of R&D spending, manage R&D wisely, and perform it efficiently; and (5) protect their intellectual property rights around the world. Strategy is also a crucial factor. Computer companies must have a good understanding of their customers' problems and needs as well as a willingness to spend money to meet those needs and solve their problems. Computer companies must also carefully assess the short and long-term advantages and disadvantages of alliances that transfer important technology to potential competitors.[42]

DEFENSE ELECTRONICS

"U. S. funded laboratories have done a superb job of spinning out the technology they developed into the commercial sector; my view is we have to do a better job of spinning in . . . from the commercial sector."[43]

For the first time in recorded history, the nation saw video footage of the deadly weapons of war in near real-time beamed by satellite into TV sets across America via CNN. Precision guided munitions launched from F-14s and F-16s used their electronic eyes to destroy well fortified bunkers; cruise missiles navigated the streets of Baghdad to find designated targets. Viewers were amazed; Americans were proud! From avionics and guidance systems to stealth technology to digital missile guidance systems all were made possible by companies in the defense electronics industry (DEI).

Hardly anyone questions the importance of this sector to our national security, but there is little consensus among the "silicon triangle" about how this industry should be positioned after DoD completes its downsizing. The silicon triangle consists of (1) government regulators and procurement officers, (2) the industry, and (3) the military who are the "requirements drivers." We will now examine some of the issues surrounding this conundrum, and offer a strategy for the success of this sector.

The Industry Perspective

"The Government is hard to do business with and we're so disgusted that we have decided to cease doing business with the government altogether!"[44] That is an extreme viewpoint, but most companies share the opinion that current U.S. laws and

rules governing procurement are too lengthy, complex, and cumbersome. To be used at all, they must be administered, interpreted, and wielded by squads of attorneys with clerical support. This adds cost to the product, while making business less efficient and more expensive to the customer, i.e., the U.S. taxpayer!

Are Milspecs necessary in all cases? Does equipment really need to operate between -60o and 150o F, when installed in an air conditioned shelter? Could the military settle for the commercial standard of -10o to 120o F, when few people could operate outside that zone for long periods anyway?[45] There are probably cases where the military may need an item custom built to very rigid specifications, but that will substantially add to the cost. Likewise, whenever a company establishes a separate production line for a military item only, that adds to the cost. Separate lines (from commercial items) yield fewer items and raise the marginal cost to the customer per item. Government supervision is costly as well. Indeed, industry has proposed and gained government agreement to set up QML processes, whereby inspectors certify a set of procedures used in the manufacturing process, and forgo individual item testing until OT&E (Operational Training & Evaluation) during Dem-Val (Demonstration-Validation) of the acquisition process.

Declining budgets translate to a lower volume of sales to DoD. This will probably mean higher item cost because the break-even point will take longer to reach, unless companies raise item prices. This sector is at a crossroads: although DoD needs semiconductors et al., more now on the <u>modern</u> battlefield, the industry really needs DoD less.[46] We have already seen that business is more lucrative in the commercial sector for most companies; however, there is also a good chance for profit in the defense industry as well. For example, from Figure 15 it appears that while the overall defense budget will decline substantially into the next century, the electronic equipment portion remains almost flat in dollars spent. The market in semiconductors for defense will remain flat at $1.4 billion a year over the next 5 years, but this is only a small percent (2%) of the total semiconductor market![47] Depicted another way in Figure 16, the trend looks even better, with electronics components absorbing a slightly rising percentage of DoD outlays.

In Figure 17, the estimated "electronic portion" of the platform sectors are shown. The electronic content is the percentage of total dollars spent on electronics. As might be expected, space has the highest percentage, but that is only one part of the story; before any company retooled its efforts, it would consider WHERE the most dollars are spent i.e. aircraft, as shown in Figure 18.

Industry appears ready to transfer technology into or out of its commercial sector where the applications are sound and the standards can be met <u>if</u> marginal revenues will <u>at least</u> equal marginal cost. For example, simulations for training and exercises are more economical and certainly continue to be an attractive alternative to full-scale military exercises. Industry would do well to pursue this market and

recognize the strong potential dual-use application of "virtual reality "games that are increasingly popular in the commercial market.

The Government Perspective

There appears to be no overarching framework for a defense industrial policy inside the current administration. Apparently they are content to allow the forces of the marketplace determine who the survivors will be, i.e. industrial Darwinism, although the Congress may choose, either for defense or non-defense reasons, to keep certain systems in production. Indeed, that approach is totally consistent with Secretary of Defense William Perry's 29 June 94 directive to convert Milspecs to industrial specs while promoting the use of commercial-off-the-shelf (COTS) products as one solution to reduced military spending and future product sources.[48] The defense electronics industry is very supportive of Dr. Perry's approach. Dr. Perry has found this to be a feasible path to reduced spending while trying to nudge the DoD toward replacing Milspecs with industry specs.

Are investment incentives for industrial base businesses to invest in infrastructure warranted? Should semiconductor manufacturing firms be allowed to depreciate their machinery over a three-year period? This would bring American business to par with our chief national competition, Japan. Is U.S. industry too focused on short-term, bottom line performance rather than long-term development? Does Wall Street encourage this attitude? Firms that do not re-invest, that do not make upgrades to their manufacturing processes, will soon be eclipsed by those who do. The Government must consider these questions, exert leadership, and adjust tax policies to restrain the natural impulses of the financial community. What area would short-term focus harm more, R&D or infrastructure? Electronics leads most other industry sectors in R&D (avg. 10%). With the gradual decrease of the length of time between product development to obsolescence, now averaging about 8 months, companies can maintain their competitive edge only by finding that new product before their rivals do. The Semiconductor Manufacturing Association recommends that the tax code be amended to allow new equipment to be depreciated at 100% over a three-year period. This would significantly encourage business investment in this sector.

The Military Perspective

The money is not there for continued development of new multiple weapons platforms. The military must consolidate and focus on joint systems that incorporate the best inter-service features. They must have smaller systems that are reliable and easier to move. Downsizing means fewer soldiers dispersed over a larger area. Soldiers may have to fight more autonomously. Large amounts of command and control (C^2) information will have to be passed around the battlefield, and this information will have to be secure from intrusion or intercept. There is some concern

that Dr. Perry's new COTS directive effectively abrogates any protection from enemy EMP (electro-magnetic pulse) that a strict Milspec (radiation hardened, "RHA") standard chip could withstand. Typical defense systems use over 90% of the same logic, memory, and IC processors as commercial chips; "Milspec chips" are screened only for the higher operating temperatures and quality requirements of Mil-Std-883.[49] The commercial sector does not demand protection against RHA; therefore the government could provide industry some of the R&D money to develop products for which there is no commercial market.[50] The defense electronics sector has been driving hard toward miniaturization in order to lighten the soldiers' load. The industry has also found a commercial market for protecting data-flow from intrusion, another example of "spinning-out" technology; Harris Corporation's Windster cryptographic module is based on a single VOLS. chip which provides a wide array of full-duplex algorithmic capabilities NSA certified to pass data through Top Secret.[51] A final problem with COTS relates to the short life of components versus the long life of military systems (15-20 years). There will be serious supportability challenges.

MANPOWER ISSUES

Work Force Turnover

Based upon our visits to various electronics firms, we learned that employee turnover within the industry has been minimal over the past year. In fact, one of the firms indicated they actually experienced no turnover during the past year except for one retirement. While this trend may be linked to downsizing efforts throughout the industry, it also implies a high degree of employee satisfaction.

Training

In addition to targeting personnel with engineering backgrounds, many of the small firms do have arrangements with high schools, junior colleges, and universities to facilitate training of potential employees. In these arrangements, firms and educational institutions decide what technical courses should be part of the curriculum. Students participating in these programs are offered on-the-job-training by participating firms. Those students who adapt well to the training and demonstrate great potential are offered full-time positions upon graduating from school. In most instances. these employees remain with the firm for many years, hence the reason for minimal employee turnover.

Skill Demands

The electronics industry primarily attracts young engineering students from co-op programs or as they graduate from college. Those young people who are adept at digitized applications or who can design processors and programs seem best suited for this field of endeavor. Locating entry-level employees does not currently seem to

be a problem for this industry. In fact, as downsizing efforts in government and industry continue, we believe the market will eventually be flooded with qualified people for electronics' industry positions. However, some firms are experiencing difficulties finding people who write well; they are in need of people who are qualified to write good proposals. In order to obtain people with this particular skill, employers are looking for people with experience in this area rather than youngsters just graduating from college. Again, the downsizing efforts will probably help in this arena as people leave government and industry positions.

One of the software firms we visited emphasized employee focus on their five guiding principles and values. They have conducted surveys and solicited feedback from contractors on employees' performance and service to determine whether or not the firm's services meet customer standards and requirements. This, of course, ties in with another one of the firm's principles--customer focus. Prior to establishing the guiding principles, this particular firm experienced high employee turnover during the time frame when the company was growing rapidly. With increased management attention on customer satisfaction and employee performance, satisfactory ratings in their external practices have increased from 68% to 85%. They are currently working on internal practices in the hopes of getting them up to 90%. This firm trains people first to solve hard problems; its leadership believes in empowering employees, granting them more authority and responsibility as they progress, This notion results in employees buying in the firm's success. Such programs are common throughout the industry.

Unions

Most of the firms we visited were not unionized. Employees have apparently concluded that unions are not required when management takes a progressive approach, applies many of the Deming principles of Total Quality Management, and empowers their employees. Those few firms that were unionized have a cooperative approach that will render the union less relevant to the firm's future success.

Labor Costs

To stay competitive, companies must reduce costs. This can be done either by enhancing productivity or by reducing wages. Although a skilled labor force is still critical, with automation performing most routine functions, many companies have opted to lower costs by reductions in unskilled labor, replacing it with fewer, more technically proficient workers. For the worker the trend is clear, the more education, the stronger the income gains; the less education, the weaker the income gain. Additionally, via modern communications, considerable competition exists with emerging countries from the East. For example, software programs can be written cheaper in India than in the U.S. So domestic labor must improve or find itself replaced by foreign workers.

Productivity

The "information revolution" may have created productivity gains, but it has also produced enormous amounts of raw data. This data must be processed in a monotonous way similar to what workers did on assembly lines. This is a major challenge. Success for the new "third wave" companies will come from the recognition that knowledge is the new hot commodity and that employee knowledge must be continuously updated. Knowledge of how to use information along with matching values and principles will form the basis for company productivity and competitiveness. A major challenge will be the cost effective processing of the onslaught of huge volumes of new information.

FINANCIAL ISSUES

The issues include: profitability and growth; producer and selling prices; shipments, inventory turnover, and revenues; business spending on new plants, equipment, and R&D; debt levels; mergers and acquisitions; and the impact of interest rates and stock prices on the industry.

Profitability and Growth

During the 5-year period ending September 30, 1993, the "computers and communications" industry was ranked first of 21 industries in sales, with 12.3% average growth, but tenth in return on equity, which was 11.9%.[52] Of the 16 industries for which 5-year average earnings per share data was provided, this industry ranked eleventh.[53]

Producer Prices and Selling Prices

Producer prices for the finished goods commodity category of "home electronics equipment" decreased by 24.4% from 1970 to 1993, including a 22.7% decrease from 1980 to 1993 alone.[54] In comparison, producer prices for the overall category of "finished consumer goods, excluding food" increased by 127.3% from 1970 to 1993, which includes a 53.1% increase since 1980.[55] Producer prices for the intermediate materials commodity category of "electronic components and accessories" increased by 102.8% from 1960 to 1993, which includes an increase of 32.7% since 1980.[56] In comparison, producer prices for the overall category of "intermediate supplies and components" increased by 129.6% from 1970 to 1993, including a 41.2% increase since 1980.[57] From 1989 to 1993, selling prices fell by 8.7% for semiconductors and related devices but increased by 5.1% for electronic components,[58] a rate of increase still below those of prices overall. Clearly the price performance of the electronics industries has been outstanding from the consumer and industrial user perspective.

Shipments and Inventory Turnover

For 1992 manufacturers' shipments of electronics (SIC code 36) and computer and office equipment (SIC code 357) totaled $275 billion, which was 18.3% of the value of all durable goods shipments. Manufacturers' inventories at the end of 1992 for those SIC codes totaled $40.2 billion, which was 17.3% of the value of all durable goods inventories. Based on this data, electronics-related inventories turned over an average of 6.84 times, a little faster than the average of 6.4 for inventories of other durable goods industries.[59]

Revenues

Information technology is an important segment of electronics. For 1993, the information technology-related revenue of DATAMATION journal's top 100 companies was $226.8 billion.[60] The top 10 companies accounted for $137.5 billion (60.6% of this total).[61] Clearly, large companies have dominance, yet there is substantial competition among firms of many sizes.

Business Expenditures for New Plant and Equipment

The electronics industry is investing heavily in new plant and equipment. Based on the Census Bureau's survey data, the "electrical machinery" industry invested $23.9 billion in new plant and equipment in 1993,[62] and planned to invest another $25.4 billion in 1994. For 1993 and 1994, these numbers were the largest for any durable goods manufacturing industry and second to petroleum among all manufacturing industries. They represented about 30% of all spending for new plant and equipment by durable goods manufacturers and 13.5% of all such spending by manufacturing industries.[63] Clearly, these are very significant industrial sectors as well as industries with substantial capital demands.

Business Expenditures for R&D

The electronics industry is also investing heavily in R&D. According to the National Science Foundation (NSF), industry funded $83.6 billion in R&D, 52% of the nation's total in 1993, and for 1991, the earliest year for which such data was available, the electrical machinery industry was the source of 16.2% (about $12.5 billion) of industry's total ($77 billion).[64] If we assume that this 1991 rate of 16.2% also applied to NSF's 1993 industry funding total, then the electrical machinery industry provided more than $13.5 billion in R&D funding in 1993.

Debt Levels

Based on Census Bureau data, the electrical and electronic industry's ratio of stockholders' equity to debt was 1.7 in 1992, compared with 1.3 for all manufacturing

corporations and 1.4 for all durable goods industries.[65] This makes these industries more sensitive to interest rate changes than the average U.S. manufacturing corporation.

Mergers and Acquisitions

A total of 314 mergers and acquisitions involving U.S. companies in the computer and office equipment electronic and other electric equipment, communications equipment, and/or computer software industries occurred in 1992.[66] The 314 transactions were valued at $6.04 billion. Three-fourths of both the transactions and the total value involved U.S. companies acquiring other U.S. companies. Foreign businesses acquiring U.S. companies represented only 9.2% of the transactions and 6.3% of their value. In the remaining transactions, U.S. companies acquired foreign ones.[67]

Impact of Interest Rates and Stock Prices

According to DATAMATION, since 1987, the companies included on its top 100 list have been struggling to overcome a sluggish global economy and adapt to changing customer needs; and in 1993, the profits of many information technology corporations regained vitality, although for many others profits were down sharply or nonexistent. In commenting on 1993, DATAMATION also stated that: " . . . In the United States, the drop in the prime [interest] rate and the record-breaking stock market rally pumped badly needed funds into companies for new product development and reorganization . . . "[68]

RESEARCH AND DEVELOPMENT ISSUES

While electronics represents the very heart of our weapon systems, provision for our future in electronics lies in research and development.

Perspective

A highly dynamic industry with a technology half-life of 8-9 months (nominal reported technology turnover time is now at about 16-18 months), electronics R&D takes on a somewhat different face than in the mechanical, industrial technologies of the past or Toffler's "second wave." The very high cost of developmental research and initial capital outlays for production will demand new approaches and adjustments in culture to evoke and nurture the "next" technology level.

As a percentage of GNP, R&D spending in the United States is lower now than it was 20 years ago.[69] Lester Thurow estimates that while our overall spending is essentially equivalent to Japan and Germany combined, our non-defense spending

has been flat at 1.7% of GNP. In 1971, the U.S., Japan, and Germany spent 1.7, 1.9, and 2.0% of GNP on non-defense R&D, respectively. By 1987, the U.S. share was still at 1.7% while Japan increased to 2.8% and Germany to 2.6%.[70] Importantly, although the United States is spending less as a percentage of GNP, we are still spending more real dollars than any other country! What the figures do say is that their *relative effort* is greater than ours.

The Electronics Industry Association's (EIA) 10-year electronics forecast is telling. Figure 19 shows R&D by funding source in the U.S. for FY 93 and calendar year 1995 projections for total funding levels of $160.7 billion in FY 93 and $182 billion in CY 95. There is an apparent increase in R&D funding by industry relative to government and this is a positive trend. And overall, the total amount of R&D increases. But in electronics, the Department of Defense (the largest government contributor) is a minuscule player. Spending on integrated circuits exemplifies DOD's share in the market. In fact, military integrated circuits barely show up on Figure 20 because DoD is such a small player. Therefore, there is little government leverage in the business.

The future of electronics is in the commercial sector, yet American corporations still depend heavily on government R&D even in electronics. The ten highest tech industries were responsible for about 50% of R&D in FY 93, and electronics accounted for about two-thirds of that.[71] Also, the American semiconductor industry effort is leading other areas by its continual R&D investment of approximately 12% of revenues.[72] All data taken together lead to several fundamental conclusions:

- The electronics industry is a commercial marketplace with little DoD influence.
- America' spending effort on non-DoD R&D is proportionally less than other nations, although the total dollars are still very high.
- Although U.S. electronics companies use the highest percentage of non-government R&D among American firms, it is not clear this is sufficient to retain our current edge.
- Only the semiconductor sector seems to plow sufficient revenues back into R&D (and the semiconductor industry itself is not certain that 12% will be enough to stay competitive).

Mechanisms for R&D in Electronics

It is an age of "dual-use," defense conversion, and diverting DoD dollars into seemingly pure commercial activities. Is this a necessary change? Internet and the Global Positioning Satellite system originated from government programs. Are these not proving to be dual-use beyond our wildest dreams? Electronics is cited as an industry whose social payoff far exceeds the normal "return on investment." DoD R&D end-products clearly have positive spill-overs. This fact, combined with the fast

technology turnover and high cost of capital in electronics, should drive policy considerations and arguments on how to deal with R&D in this sector. Clearly some public subsidy is warranted.

In the 1980's, our semiconductor capability seemed to fall behind "the competition." The U.S. Government partnered with industry in the renowned effort called SEMATECH. Considered a huge success by many,[73] the companies involved feel that the government has done its share and now advocate its pull-out.[74] In fact, the same speaker who brought this news felt that electronics firms would prefer tax breaks and other incentives in lieu of outright contributions toward development of electronics capabilities. Tax breaks or government subsidies in this industry seem necessary because of the positive spillovers generated and because the tremendously high costs of research and development are too much for segments of the industry to handle on their own. Clearly, coalitions are one answer to this dilemma. The issue is whether or not the government plays and /or pays in the coalition ventures and what antitrust issues may be relevant.

EIA's report on the electronics industry draws several conclusions. First, there is little place for industry in the area of basic research.[75] It also suggests that the place for industry is the 6.3A arena, DOD budget jargon for research that has potential for transition to production use. This is a precarious recommendation since it leaves fundamental research to government funding and brings industry in to capitalize only after technologies have proved their worthiness. The risk? - according to a spokesman for the Semiconductor Industry Association (SIA), Congress is trying to cut another $300 million out of the 6.1 R&D arena in FY 95 after already cutting $220 million in FY 94.[76] Industry desires are not in line with the reality of federal budget cuts!

Another characteristic in this industry segment that may be common to other industries is the tendency for American companies to spend more R&D toward new product invention instead of manufacturing processes innovation. This may need to be reevaluated because some say reverse engineering in this field is now an "art form" where anyone can recreate a new product. The trick is getting new products produced cheaper than the next guy.[77] America spends about two-thirds of its R&D on new product development, while the Japanese, for example, spend about two-thirds on process development. Where is the balance? An interview with Dr. James Glaze of the SIA revealed that concentration on production processes was probably the most instrumental factor in SEMATECH's success.[78]

Here are some overriding characteristics of R&D in the electronics industry:

- Basic research is being supported by an ever-decreasing government investment.
- Industry tends to concentrate on bringing new technology to market instead

of inventing the new technology.

- The high cost of R&D and cost of capital compel the use of coalitions.
- U.S. firms spend relatively more R&D dollars on new products while others spend more on manufacturing processes.
- OVERALL, U.S. electronics R&D is nonetheless healthier than that of other nations.

INTERNATIONAL COMPLICATIONS

Worldwide electronics production performance data give a good picture how American electronics firms are doing globally across all sectors of the industry (see Figure 21).

Export Performance

Based on 1992 data (Figure 21), the U.S. is clearly the world electronics leader, with roughly 35% of world production. U.S. firms dominate in only a few specific categories, those in the higher-end, most critical for national defense, e.g., instrumentation, active components, and computing. Aggregate sales for Japan and Europe are roughly equivalent at one-quarter of world output. Japanese firms lead in consumer electronics and components, while Europe leads in telecommunications. More recent data reflect these same patterns. Not surprisingly, American electronics firms and their lobbies are quick to complain to the Administration, to Congress, and the news media that they must compete in foreign markets where indigenous firms have many advantages due to foreign trade barriers and cultural barriers (such as Japan's vertically-integrated *Keiretsus* and their closed system of doing business).

These same American firms also assert that they are victimized in the larger global market as well, due to aggressive foreign government investment or subsidization of competitor firms. To be sure, there are cases where foreign governments and cultures are better organized, more inclined to prop up their industries, and do place barriers in the way of American firms, such as in the case of semiconductors. In these cases, the U.S. Government attempts to safeguard American manufacturers by pushing bilateral trade agreements with the target nations. These agreements are designed to ensure market share for U.S. products, but usually have mixed results, e.g., the U.S.- Japan Semiconductor Agreement, applauded by the semiconductor industry, but condemned by semiconductor users!

- **Consumer Electronics** U.S. consumer electronics firms, the companies that make TVs, VCRs, and portable and home audio components have increased exports over the period 1991 to 1993. Imports have also increased over the same period and are roughly six times greater than exports. This is an extremely globalized production process, with much of the domestic sales of American companies actually produced offshore. Further, because of fierce global competition (and lower offshore labor costs) in consumer electronics, many U.S. companies made a business decision to withdraw from this low profit arena and let foreign companies fight over the

"crumbs."

• **Computers and Peripheral Devices** U.S. firms are dominant in the global market share for computer electronics, but lose the lead to Japan for office equipment and peripherals. But the public tends to focus on the balance of trade alone, which shows that Americans buy more foreign goods in these categories than U.S. firms export. This suggests a weak performance, but ignores U.S. sales to the world's largest market--the U.S.!

• **Defense Electronics** U.S. firms are hindered by their government for national security reasons from selling the best defense electronic technology overseas outside the carefully managed, government-directed Foreign Military Sales (FMS) program. U.S. firms are also hampered by the fact that while the U.S. military may require "Cadillac" versions of defense electronics, foreign markets may opt for other nations' "Volkswagen" versions of the same kind of technology, thus making it hard for U.S. firms to be competitive. Nevertheless, U.S. firms do sell overseas: for example, export of sonar systems and equipment has steadily risen from $1.3 billion in 1983 to approximately $2.5 billion in 1992. During the same period, U.S. manufactured electronics for missile and space vehicle systems rose from $1.8 billion to $4.6 billion in components and devices. Yet U.S. dependence on imports has also grown. From 1982 through 1989, U.S. imports of semiconductors as a share of total semiconductor consumption ranged from 56.8% to 62.5% (During this same period, Japan's dependence on Japanese electronics products as a source rose from 7.5% in 1982 to 21.1% in 1989.[79]). Japan also provides the only source of ceramic packaging for semiconductors, and presently dominates the supply of flat panel display technology--95%.[80]

Of the top ten foreign suppliers of electronics to the U.S., Japan leads with $34.8 billion of sales in 1993. Singapore came in second with $9.6 billion. Overall, Asia provided the U.S. market with approximately $78 billion in imports in 1993.[81]

Licensing and Intellectual Property

U.S. law is undergoing revisions on what constitutes reasonable protection for patents and intellectual property in the Information Age. Recent examples of litigation in these areas can approach absurdity. For example, in August 1994 the Tokyo District Court ruled in favor of the Japanese firm, Fujitsu, over Texas Instruments claims of patent violation on a 1965 computer chip patent.[82] This case, and many more, shows the need for harmonization of policies concerning intellectual property and patents.

U.S. Competitiveness and the Government's Role

The U.S. has many evident strengths with which to compete in the international

market. It must nurture those strengths: R&D, marketing, management, competitive spirit. The U.S. will be unable to match the low wage scale so prevalent in the emerging nations. Raising labor and capital productivity should be our prime goal.

MAJOR MANAGEMENT CHALLENGES

In the Reagan years, when the Soviet Union still represented a viable threat to world peace, the United States defense industrial base received a shot in the arm. According to Kenneth L. Adelman and Norman R. Augustine in their book The Defense Revolution, "Since World War II, defense budgets tended to hold steady in real terms during peacetime at a level of about $250 billion per year in today's dollars. The exception to this is the Reagan military buildup, during which spending reached about $300 billion per year." This translated into plenty of contracts for all. Management challenges centered around production schedules, how many more technical and skilled laborers could be found and brought on line, improving some of their facilities, and increasing the sizes of the corporate staffs. Since that time, however, the Soviet Union collapsed, the Warsaw Pact has broken up, and the identifiable enemy has become invisible. That puts a different slant on the management challenges now faced by the defense electronics industry.

Downsizing

No longer flush with high defense budgets and plentiful procurement contracts, the Department of Defense (DoD) and the defense industry have had to regroup. According to an article in Parameters, U.S. Military Ammunition Policy: Reliving the Mistakes of the Past? "Between 1985 to 1994, the inflation-adjusted buying power of the Pentagon's procurement budgets fell by 64 percent, compared with a more moderate 34-percent decline for overall defense spending." Another source "Building Future Security: Strategies for Restructuring the U.S. Defense Technology and Industrial Base," an Office of Technology Assessment staff project, forecasts that "By the end of the decade, the defense budget could well be between $180 and $200 billion in 1992 dollars." Further, it could get even worse. Defense companies and, in particular, those in electronics we visited, received the message loud and clear. For the most part, they have taken steps to downsize their defense production facilities and capabilities. In a November 1991report to Congress on the Defense Industrial Base, the Under Secretary of Defense Acquisition (Production and Logistics) explains,

> "The financial strength shown by most commercial electronics companies is attributable to the continuing growth of the electronics market and to the size and diversity of the companies examined. It is noteworthy that all are planning for reduced defense spending by concentrating on high-technology defense segments that they believe will fare better over the next few years and by reducing their overall reliance on defense sales. They are also diverting some of their segments to reduce their Government dependence."

Additionally, these same companies are trying mergers, international strategic alliances, restructuring, laying off workers, and renegotiating union contracts and workers benefits, while some are simply going out of business. In trying to understand the cost containment exercises companies are going through, perhaps it would be beneficial to enumerate some of the factors that influence a company's cost of doing business--labor, raw materials, energy, interest, taxes, and general management costs. One firm indicated that in downsizing its labor force it makes every effort to retain people who have contributed the most to be growth of the company. It further related that when the initial cuts take place the first people to go are the marketers. Another firm stated that one of its biggest concerns (shared by other companies as well) about downsizing is loss of skilled laborers, knowledge, capacity, and capability in the labor force. This raises some questions concerning reconstitution.

Strategic Issues

In an article written for National Defense, Robert H. Williams quotes C. Michael Armstrong, Chairman and CEO of Hughes Aircraft Company and GM Hughes Electronics as saying " . . . industry consolidation and mergers constitute both an "economic and national necessity." Armstrong adds that "successful defense contractors also need to diversity . . . " This will be key in maintaining an "efficient, critical mass," adding that "diversification into the commercial sector will be no easy matter." Using teaming agreements and strategic alliances and forming consortiums are common means for all the participants to get new ideas and new business. Very recently The Washington Post reported on the merger between two industry giants, Lockheed and Martin-Marietta. The story described how their consolidation will enable them to be more competitive and complement each other's strengths. Their plan is to "accelerate movement to dual-multi-use acquisition" through the following:

- Eliminate barriers to dual-use; multi-use, in process reviews, partnerships.
- Develop consensus on use of commercial practices, expanded use of COTS and NDI.
- Manage by new product families not program by program.
- Design for dual-use technology: materials, parts, processes, sub-systems.

Another company discussed three elements of its strategy: diversification and conversion of technologies and skills, international sales, and utilizing synergistic opportunities to access new markets. It restructured its corporate organization and employment levels were reduced; it recently acquired another company to participate in another sector. In 1993 and 1994, this company instituted further major initiatives in technology diversification and conversion technology. Many have made moves toward converting some of their defense technology into the commercial world.

It was evident throughout our visits that the defense electronics companies have heard the message and are taking action to adjust to current drawdowns. They

are seeking to restructure, consolidate, and become internationally competitive. While few expressed a desire to abandon their commitment to national defense, all acknowledged that their future survival depended on commercial competitiveness. This is the wave of the future if they are to survive and be available to mobilize and reconstitute in times of crisis.

GOVERNMENTAL IMPACTS

Acquisition Trends

Changes in the acquisition process since the horror stories of the early 1980s have been substantial. Further, this new world brings a drastically reduced budget, a more amorphous threat, and technology changing faster than the acquisition system can respond to.

The electronics industry is currently assessing the impact of the new way of doing government business within the new acquisition guidelines. The commercial off the shelf (COTS) approach brings many new challenges which need to be evaluated by government and industry.

The proliferation of weapons of mass destruction, both nuclear and non-nuclear, and the possibility for failure of the democratic process in Russia continue to represent threats. In the meantime, the U.S. is involved in new endeavors like peacekeeping, peacemaking, and various humanitarian missions. What does this do to American military forces? It has certainly changed their mission, with their defense budget now spread to multiple missions of humanitarian assistance. The DOD budget has been reduced by 40% while the procurement accounts have been reduced by over 65%. Downsizing means providing the most modern equipment to a smaller number of troops.

Technological superiority vs. numerical superiority is a topic of great relevance to the electronics industry. The current DOD acquisition system, lacking flexibility, is not geared to accommodate quick technological advancement. Technology transfer is also a problem: "The building blocks that make up our fundamental major weapons systems are primarily electronic in nature, and that electronic capability is too easily spread around the world. Our past strategy of being able to keep technology secret, therefore giving us an advantage over our opponents, is no longer a viable strategy."[83] The nature of the current threat is unpredictable, so the acquisition system must be more flexible. The trade-offs made between cost, schedule, performance, and reliability are now dictating affordability as the major criterion. The goal of those in the management of the acquisition process emphasizes that the Department of Defense must become the world's smartest buyer of best-value goods and services that meet user needs. As part of this change, the military must retain the public trust and support of the nation's socioeconomic and industrial base goals. To be accomplish

this, we must have acquisition initiatives that assist us in what we buy, how we buy, the terms and conditions of the purchase, and implementing world-class abilities in our acquisition approach.

This mandates that we change our "paradigms" and ways of doing business. The first step is the acceptance of these new realities. We cannot continue to conduct business the way we have in the past. We must reduce acquisition costs by adopting successful business practices from the commercial marketplace. But how can we do this within the electronics industry? The COTS approach brings security issues that we have not worried about in the past. Suppose the manufacturing of semiconductors to ILO Milspecs is acquired from overseas firms. There are national security implications if we choose to rely upon other countries for re-supply of this technology under other than peaceful conditions. Do we know that these countries will be there to support us in war? What impact will the short lives of commercial components have for the maintenance of far longer-lived defense systems?

In the near future the government's semiconductor business will not exceed one percent of this market. The Department of Defense truly has a challenge in how it will keep this industry responsive to the future security needs of our Nation. There is a need for a plan that promotes the use of best practices and technologies to assure a strong electronics industrial base that is responsive to both military and commercial needs. The Electronic Systems Center, Air Force Materiel Command, Hanscom AFB, MA has focused on a strategy for the years 2000 and 2005 by product area. The elements included are radar, electronic countermeasures, communication, navigation/guidance, and electronic packaging. A strong laboratory emphasis is vital for the participation and management.

Another very important element of the electronics and semiconductor industry is the thrust in product definition. We must define requirements that encourage design, feasibility, and support via dual-use factories. Some of the areas of opportunities are: dual-use awareness in customer/user, affordability emphasis in concept definition, dual-use design/product verification practices, emphasis on existing products/components, and dual-use simulation modeling tools. The removal of barriers to good business practices can also be implemented at the policy level; some of these barriers include excess government oversight, data rights, warranties, best value suppliers, and affordability incentives.

MOBILIZATION ISSUES

For four decades, our nation pursued a national strategy of containment, focused on a single adversary--the USSR--with the objective of preventing general nuclear war. During much of that time, a policy of Mutually Assured Destruction (MAD) dominated, and little thought appears to have been devoted to industrial mobilization. This concept was joined with the idea that a conventional war, perhaps

limited to the use of tactical nuclear weapons, could be fought and won in Europe. Defense spending was sustained at record levels for years under the Reagan Administration. Domestic defense contractors in all industry sectors were healthy. Industrial mobilization was indeed a viable possibility. Then a New World Order emerged. The United States initiated a major overhaul of its armed forces, reducing their size, infrastructure, and budget. The National Security Strategy changed. Military strategy, facing massive spending cuts, changed too; emphasizing a smaller active force, and becoming reliant on the nation's ability to mobile should a crisis appear. But as the military shrunk, so too did defense industrial capabilities.

The Challenges In the face of defense cutbacks, the electronics industry in the U.S. faces a number of challenges. Some are listed here, then discussed in further detail in subsequent paragraphs:

- Existence of an industrial base
- Ability to ramp up production to wartime demands
- Bottlenecks in the process
  Cost
  Legal complications

The Industrial Base

The U.S. currently enjoys a competitive advantage in systems integration; that is, the process of integrating electronic commodities into working systems designed to satisfy a requirement. Firms like Loral, TRW, Harris, and E-Systems remain strong in this market. U.S. firms also remain strong in the design and engineering of integrated circuits. But packaging and assembly processes have moved largely overseas. In the 1970s and 1980s, Japan succeeded at becoming the dominant leader in semiconductor manufacture, athough in the 1990s the U.S. regained the world market share lead. The strength of U.S. firms is mostly in specialized integrated circuits, like microprocessors and application specific integrated circuits (ASICs). But the Japanese still lead in the industry's pacing item, the dynamic random access memory, or DRAM. Their only serious competition in DRAM production arises from other Pacific Rim nations. So, there are clearly some offshore dependencies.

Wartime Production Surge

With much of this industrial base overseas, a question is raised about our ability to ramp up production in time of crisis. However, there is little cause for concern. First, it is very difficult to measure our true production capacity because of the market structure. The U.S. domestic electronics market is divided into the merchant market which makes the commodity ICs for general sale and use, and the captive market, where a large semiconductor user like IBM who make their own ICs. How much capacity exists in the captive market, and to what extent it could be used in a national

emergency is unknown.[84] This would certainly seem to depend on the nature and degree of the threat. Second, offshore production facilities could meet U.S. surge requirements, if motivated to do so. Major factors in this regard have to do with how closely the potential source's security interests are aligned with those of the U.S., and in the political climate of the source's nation. Finally, as the defense drawdown continues, it is likely that IC manufacturers' suppliers may dwindle as well. The electronics industry relies on machine tool, vacuum control, computer aided design, and automatic control industries, so there are some questions in this arena.

The Bottlenecks

Military specifications (Milspec) and the Federal Acquisition Regulations (FAR) seem to represent the major bottlenecks in maintaining and surging an electronics industrial base. MILSPECS add time and cost to electronics manufacture. Their use discourages commercial firms from entering the defense market, and they may hamstring development of dual-use technology. The need for reform of Acquisition regulations is now well known. Although they can be by-passed during a national emergency, their complexity discourages entry into the defense electronics market. As noted earlier, the danger to the electronics industrial base is the disappearance of the small firms supplying materials and equipment to the large defense electronics companies. "Small Business Set-Asides" notwithstanding, it is the complexity of Federal Government contracting that keeps the small businesses away.

Cost Prospects

Military suppliers "get well" during war and defense build-ups. Assuming the existence here, or abroad, of a reliable, adequate electronics industrial base, we would expect costs to rise somewhat in a crisis. Increased staffing, overtime wages, raw material, and quick response premiums will all add to the real cost to the manufacturer. The opportunity for increased economic profit will not go unnoticed, so the final cost to the government and, ultimately, the taxpayer will go up even more.

Of more interest, perhaps, is the cost of maintaining a domestic industrial base. As previously stated, system integrators and electronic systems builders are healthy. But their domestic sources of basic raw materials - semiconductors - have decreased. Just to get started in the semiconductor manufacturing business costs $1.5 to $5 billion. The financial system in the U.S. often finds banks generally unwilling to lend that kind of money. If it can be borrowed, high interest rates can eliminate much chance for profit. U.S. tax laws often provide a hostile environment for new ventures. Additionally, there exists a significant learning curve attendant to the manufacture of integrated circuits, but the most successful producers are the ones first to market with a new product.

Legal Complications Legal complications facing mobilization of the electronics industry include anti-trust laws and applicability of the *Defense Production Act of 1950.*

The Japanese prowess in the semiconductor industry is, at least in part, often attributed to the support provided by their government to business, and cooperation among different businesses, as well as acceptance of trade practices considered illegal in the U.S. under our anti-trust laws. Similar inter-business cooperation is often touted as a partial solution to U.S. industry woes. But such practice, although unclear as to how helpful this would be, may be illegal here, and would require exemption from the Sherman Act and other laws.

The Defense Production Act empowers the President to direct domestic production output to wartime needs. A number of foreign firms operate electronic production facilities on U.S. soil, to the mutual benefit to U.S. workers, consumers, the foreign firm, and its local domicile. Whether the Defense Production Act applies to such foreign owned facilities is questionable, and although U.S. security interests would ultimately win out, the U.S. legal system could certainly slow progress. Likewise, U.S. firms operate on foreign soil, purportedly to avoid the U.S. legal and regulatory climate. It is not clear whether U.S. firms operating overseas will always act to support U.S. national interests if they conflict with business interests or host nation policies.

Other Complications One major complication is the lagging education system of the U.S. A few decades ago, it was the best in the world. Today, it seems not to have held its position. Unfortunately, the rest of the world has caught up - and passed us by. It is widely held that we are entering a new era, the Information Age. Technology, fueled by computers and robotics, will come to dominate where machinery dominated in the Industrial revolution. This requires a technically capable work force. The other obstacle, which to a degree extends from the first, is our political system and its participants. National leaders come from the ranks of lawyers and financial managers, not scientists and engineers. Our national leadership is largely illiterate in high technology matters. This, coupled with a political process dominated by lobbies and special interest groups and conforming to complex Congressional organization, makes it difficult for busy lawmakers to grasp the long-term security implications of our high technology industries.

OUTLOOK

View of the Electronics Industry in the near term Despite problems, the future of the U.S. electronics industry looks promising in both the defense and commercial sectors. One of the major reasons for the industry's success is the high level of competition in the U.S. market. The U.S. market for telecommunications, electronic components, computers, and electro-medical devices, as well as industrial and consumer electronics is the most competitive in the world. U.S.- based producers are

also very competitive in the global market, exporting components and finished electronic goods to over 100 countries. From 1990 through 1993 U.S. factory sales of electronics grew at a rate of 7% (see Figure 24).

The defense electronics industry, despite the downturn in defense spending, can look forward to a number of years of moderate growth. Even though the defense procurement budget is declining, spending on upgrading existing systems will result in an increase in total dollars spent on defense electronics. There are also brightly spots for the commercial electronics sector, where the continuing strength of the Yen and positive developments in HDTV promise financial rewards. Areas in the commercial electronics area that look the most promising are telecommunications, electro-medical equipment, and electronic components.

Telecommunications The U.S. telecommunications market has been growing rapidly since 1990. The major areas of expansion have been in fiber optic cable systems, growing at a rate of 13% a year, and satellite communication systems (see Figure 25). U.S. satellite operators represent the largest market for commercial comsats in the world. The proposed constellations of smaller satellites to provide worldwide personal cellular phone access will fuel high growth in the communication industry. In total, the current plans call for more than 270 of the smaller satellites, involving an investment of over $4 billion. U.S. manufacturers have 60% of the world's commercial communication satellites. The U.S. is the acknowledged leader in developing new technology and markets for small satellites and for mobile satellite navigation and tracking services. Virtually all commercial satellites contain some U.S. technology. The growth in U.S. factory shipments of telecommunications equipments is depicted in Figure 25.

Another area of rapid growth in the communications field has been in the cellular phone market, which has increased 500% from 1989 levels. U.S. factory sales of cellular phones and cellular accessories are projected to grow 7% and 22% respectfully from 1993 to 1998 (see Figure 26).

Electro-medical Equipment U.S. exports of electro-medical equipment increased nearly 8% in 1993 to $8.1 billion, providing a $4.4 billion trade surplus (see Figure 17). Major exports in this sector were electro-diagnostics devices, ultrasonic scanners, and patient monitoring systems. According to the Department of Commerce, nuclear medicine, with 8% growth in 1994, is one area that is expected to show continued growth.

Electronic Components The growth in U.S. manufactured electronic components, which includes electron tubes, solid-state products, and passive and other components, has been substantial (see Figure 28). Growth is expected to continue as foreign manufacturers move production facilities to the U.S. In CRT production, the trend to large size TV sets has meant it is more efficient to produce the sets and

CRTs locally, close to the largest TV market in the world. Future growth in the TV market is expected to average 3.5+% per year through 1998. And continued growth in the computer and telecommunications industries is expected to maintain the increasing demand for solid-state products such as integrated microcircuits and random access memory.

CONCLUSIONS

Generally, the United States electronics Industry is strong in 1995. An exception to this may be the foreign lead in consumer electronics, a low profit arena. Anticipated trends over the next several years favor increased growth and prosperity. Some further conclusions are listed.

- **The U.S. Semiconductor Industry** is presently very strong. Conditions seem to have stabilized in recent years, but as we found in the past, there are no guarantees. U.S. market share is on the rise and revenues are accelerating. The industry is future oriented, best exemplified by the National Roadmap prepared in 1994. Without question, semiconductors remain a critical element in national defense since our weapon systems are increasingly dependent on electronics and miniaturization.

- **Mobilization** The domestic defense electronics industrial base can surge to wartime needs, if its basic inputs are available. That will depend on the viability of domestic suppliers to the industry and does entail some degree of foreign dependence. Foreign dependence in this industry is not necessarily bad; at present, the dominant foreign manufacturers are in nations whose interests align with our own. Further, foreign manufactured semiconductors are easily airlifted to locations.

- **Electronics Research and Development Policy Options**

1. Develop policies that will encourage more investment in research and development across the spectrum, from basic research to commercialization.
2. Continue to allow and encourage the formation of coalitions to develop precompetitive products and processes.
3. Encourage U.S. firms to balance their investments between creating new products and developing manufacturing processes.
4. Specifically, develop policies to use or adapt commercial electronics products and architectures for use in government and defense procurements
5. The government should NOT invest directly in commercial electronics coalitions or R&D ventures.

Finally, we offer some **overall policy options** to consider for keeping the electronics industry viable for years to come:

- Encourage joint ventures between domestic and foreign companies. The Department of Defense may find it more palatable to depend upon a joint venture than on an entirely foreign-owned firm. This may also ease the financial problems attendant to market entry, and help keep an active skill base.
- Institutionalize a series of national-level war games that address the issues of dependence on foreign suppliers. Assess the conditions under which likely trade partners will find their security interests aligned with those of the U.S., and the situations wherein the political climate may preclude their cooperation.
- Government trade intervention. This is clearly an option, but not a good one. The 1986 semiconductor trade agreement achieved mixed results at best. The trade sanctions applied against Japan did not reinvigorate our position in the DRAM market and did raise prices for U.S. users, including exporters.
- Eliminate or reduce MILSPECs. This is a popular, but somewhat mixed option, with some possible favorable results. MILSPECs make entry to defense electronics ventures undesirable. But MILSPECs exist for valid reasons. There may be systems for which no valid MILSPEC requirement exists. In these cases, commercial products would serve well. An analysis of this matter is complicated, however, by the lack of a data base detailing what systems use what parts.
- Build a data base of electronic parts and components used in DoD. This is critical to identifying critical components, foreign dependencies, and potential relaxation of MILSPEC requirements.
- Establish economic policies that favor participation in the industry, then resist the temptation to "help" through over-regulation and excessive government auditing.
- The government needs to press swiftly for acquisition reform. Most of the regulatory and procurement regulations do not apply well to NDI. This is incongruent with a DoD push toward more COTS procurement.
- Allow Industrial Darwinism to continue, but retain one-of-a-kind capabilities, keeping them *warm*.

The electronics industries are a key to the future of America's competitiveness and national defense. We must sustain useful levels of cooperation and a high degree of international competitiveness.

GLOSSARY

Angstrom. A unit of length equal to one hundred-millionth of a centimeter.

ASIC. Application Specific Integrated Circuit. Integrated circuit tailored for a particular application, e.g., signal processing. Contrasted with the large variety of general purpose integrated circuits such as logic circuits, timers, memories, etc.

Bipolar Technology. A particular method of design of semiconductor circuits. Contrasted with Metal Oxide Semiconductor (MOS) and Complementary MOS (CMOS) technology. Bipolar devices provide high speed, but consume a lot of power.

Chip. Tiny piece of semiconductor material on which an integrated circuit of hundreds to many thousands of individual circuit devices is fabricated.

CMOS. Complementary Metal Oxide Semiconductor. A semiconductor technology with advantages in lower power consumption and greater noise immunity than many other technologies.

Gate. An electronic circuit that can be fabricated on a semiconductor chip, that is one of the basic building blocks of complex digital circuits.

Gate Array. An array, or gridwork of gates. Often programmable, as in a Field-Programmable Gate Array.

MOS. Metal Oxide Semiconductor. A semiconductor technology that uses metal oxide (basically, rust) to insulate various regions on a semiconductor chip.

Semiconductor. A crystalline substance such as germanium or silicon, that has electrical conductivity greater than an insulator, but less than a conductor.

ENDNOTES

1. 1994 Annual Data Book Semiconductor Industry Association.

2. 1994 Annual Data Book Ibid.

3. "Koreans Move to Grab Memory-Chip From the Japanese", 3/14/95, Associated Press.

4. 1994 Annual Data Book

5. International Trade Reporter, Dec. 21, 1994.

6. Ristelhueber, Robert "Setting Sun: The Slide of Japanese Semiconductors", Electronic Business Buyer, April 1994.

7. 1994 Data Book

8. Computergram International, 11 Oct 1994, No 2519.

9. 1994 Data Book

10. National Technology Roadmap for Semiconductors, p.6, 1994

11. National Technology Roadmap for Semiconductors, 1994

12. 1994 Data Book

13. Leow, Claire, Business Times, 17 Jan 1995.

14. Associated Press, 1 March 1995

15. National Technology Roadmap for Semiconductors, Introduction, 1994

16. Defense Technology Plan, p. 10-5, 1994.

17. Helm, Leslie, Los angeles Times, Oct 7, 1994.

18. Brett and High, SIA, U.S. Newswire, Mar 94.

19. Juliussen, Karen Petska and Juliussen, Egil Computer Industry Almanac, 1993, p.2.

20. Phone interviews with Tim Miles and Rebecca Kraft, Department of Commerce, and receipt for written, unofficial Department of Commerce documents, which are specifically "not available for public release, on March 9 and 25, 1995.

21. Parts and components relating to computers and peripherals are included in each of these categories, as appropriate.

22. Op Cit. 19, pp. 3-4.

23. Op Cit 20.

24. Computergram International, July 15, 1994, based on Computer Industry Almanac 1994-1995, pp. 17-18.

25. As of mid-March, a Commerce Department official said the information provided to me was not available for public release, but was available for National Defense University research and internal reporting purposes (see bibliography item #2). This official expects the information to become available in April 1995.

26. Op Cit 20.

27. U.S. Industrial Outlook 1994, U.S. Department of Commerce, International Trade Administration, U.S. Government, p. 26-1.

28. The Department of Commerce defines the "product shipments" as the value of products that are classified in the computers and peripherals industry produced by all industries.

29. Based on the most recent information available in mid-March 1995, all of the Commerce Department numbers shown in this report for 1993, as well as those for 1994 and 1995, are still estimates.

30. Op Cit, 20.

31. Op Cit. 27, p. 26-2..

32. Op Cit. 20.

33. Op Cit. 20.

34. Op Cit. 20.

35. Op Cit. 20.

36. Op Cit. 20.

37. Op Cit. 20.

38. Op Cit. 20.

39. Porter, Michael E. The Competitive Advantage of Nationals, New York: The Free Press, 1990.

40. Op Cit. 20.

41. Op Cit. 27, p. 26-7.

42. Ibid. and Op Cit. 39.

43. Hon. John Deutch, Dep Sec Def while speaking from prepared remarks at NDU in 1995.

44. A Senior executive with a large multinational electronics corporation with headquarters in the U.S. made this remark when speaking to the Industrial College of the Armed Forces class of 1995.

45. Using COTS Equipment in Military Applications, Bill Oehme, Defense Electronics, March 1994.

46. Defense Electronics Weathers DoD Storm, Ron Hehr, Defense Electronics, January 1994.

47. Ibid.

48. The DoD Directive---What about radiation Hardness?, Michael C. Maher, Defense Electronics, October 1994.

49. Op Cit. 44.

50. Op Cit. 46.

51. The Dynamics of Information Security, Chester A. Massari, Defense Electronics, August 1994.

52. These numbers are based on the results of the 1,305 largest publicly owned U.S. companies in Forbes' universe. The averages are industry medians.

53. Department of "Commerce, Economics and Statistics Administration and Bureau of the Census, The American Almanac, Statistical Abstract of the United States 1994-1995 The Reference Press, Inc., Austin, Texas (August 1994), p. 558, Table 869.

54. These numbers are based on the Department of Labor, Bureau of Labor Statistics' producer price indexes and 1982 constant dollars. Ibid. p. 497, Table 754.

55. Ibid. p. 496, Table 753.

56. From 1989 to 1993, these prices decreased by 1.3 percent compared to an 8.3 percent average increase in the overall intermediate materials, supplies, and components category. Ibid. p. 498, Table 754.

57. Ibid p. 496, Table 753.

58. Price indexes are based on selling prices reported by establishments of all sizes, selected by probability sampling. Industries were selected based on value added. Ibid. p. 498, Table 755.

59. Ibid, p. 774, Table 1263.

60. Information technology-related revenue encompasses sales of general purpose products and services, including computers of all sizes, software, data communications, and maintenance, but excludes equipment leasing, basic rate data transmission services, instrumentation, automatic test equipment, supplies (except for magnetic media), industrial control devices, central office switches, analog PBXs, and computer output micrographic systems. From DATAMATION, June 15, 1994, p. 45.

61. The top 10 companies in terms of 1993 revenues were: IBM, Hewlett-Packard, Digital Equipment, AT&T, Electronic Data Systems, Apple, Unisys, Compaq, Sun Microsystems, and Microsoft. From DATAMATION, June 15, 1994, pp. 66-92.

62. The U.S. Bureau of Economic analysis, Department of Commerce, reported that, in 1992, the "electronic and electric equipment" industry held $181.8 billion in fixed private capital. This represented 15 percent of all fixed private capital held by durable goods manufacturers. However, the "industrial machinery and equipment" industry accounted for another $208.6 billion, which included both electrical and non-electrical machinery. Op Cit. 51, p. 554, Table 861.

63. Op Cit. 51, p. 555, Table 863.

64. Ibid. pp. 608, and 612, Table 966 and 974.

65. These numbers exclude corporations with less than $250,000 in assets. Manufacturers' and durable goods industries' stockholders' equity totaled $1,035 billion and $474 billion, respectively, while their debt totaled $819 billion and $335 billion, respectively. Ibid. p. 561, Table 876 and 877.

66. This represents about 23 percent of all such transactions in U.S. manufacturing industries and $6,041 million represents 15.5 percent of their value.

67. Op Cit. 51, p. 55, Table 856.

68. DATAMATION, June 15, 1994.

69. Thurow, Lester, Head to Head, 1993, p. 157.

70. Thurow, Lester, p. 157.

71. National Academy Press, The Government Role in Civilian Technology, 1992, p. 11.

72. Tyson, Laura D'Andrea, Who's Bashing Whom?, Trade Conflict in High Technology Industries, November 92, p. 32.

73. Rosenker, Mark, Electronics Industry Association, Visit to Electronics Group, Spring 95.

74. Deiniger, C. Richard, "SEMATECH: A Successful Collaboration Between Industry and Government", American Society for Information Science, Jun/Jul 94.

75. Briefing to Electronics Industry Group, Spring 95.

76. Bethea, Margo, EIA Ten-Year Forecast, 18th Annual Report, 1993.

77. Glaze, James A., SIA, telephone interview, Mar 95.

78. Thurow, Lester, p. 45.

79. Glaze, Jame A.

80. Tyson, Laura D'Andrea, Trade Conflict in High-Technology Industries, Washington, DC: Institute for International Economics, November 1992, p. 129.

81. Business Week, July 5, 1993, p. 32.

82. EIA 1994 Electronics Market Databook

83. Wall Street Journal, September 1, 1994.

84. Thurow, Lester. Head to Head, The Coming Economic Battle Among Japan, Europe, and America. Warner Brooks: New York 1993, p., 293.

INDUSTRY STUDY

#9

ENERGY

TABLE OF CONTENTS

PARTICIPANTS

Students

LTC Steve Barth

Mr. Richard Byess

Ms. Betsy Connell

CDR Robert Elliott, USN

Mr. Alan Estevez

CDR Joe Harriss, USN

CDR Don Hayes, USN

CAPT Michael Landers, USN

COL Dave Lenz

Ms. Patricia Radar

COL Ramona Stelford, USAF

Mr. Nick Sherwood

LTC Robert Veale, USAF

Mr. Ed Thomas, D/A

Faculty

Dr. Robert Pirog, Primary

Dr. Maureen Crandall

COL Mike Lyga, USAF

PLACES VISITED

Domestic

ARCO Marine	Long Beach, CA
Bechtel Corporation	Daggett, CA
California Energy Commission	Sacramento, CA
Chevron Corporation	San Francisco, CA
CONSOL	Morgantown, WV
Daggett Leasing Corporation	Daggett, CA
Department of Energy	Washington, DC
KJC Operating Company	Boron, CA
Mogantown Energy Technology Center	Morgantown, WV
PEPCO	Dickerson, MD
Sacramento Municipal Utility District	Sacremento, CA
Sea West Wind Facility	Mojave, CA
Solarex Corporation	Frederick, MD
Three Mile Island Nuclear Power Plant	Middletown, PA

International

Compagnie Generale des Matières Nucleaires (COGEMA)	La Hague, FR
Enron (gas and cogeneration plant)	Teesside, UK
FRAMATOME	Paris, FR
International Energy Agency	Paris, FR
International Petroleum Exchange	London, UK
Shell International Petroleum Corp.	London, UK
Société National ELF Aquitaine	Paris, FR
TOTAL Raffinage Distribution	Paris, FR

INTRODUCTION

The energy crisis entered the American psyche a few months after the Yom Kippur War in the winter of 1973-1974. In the more than 20 years since then, the Organization of Petroleum Exporting Countries (OPEC), price spikes, energy dependence and independence, sustainable energy, and energy security have become everyday phrases in our national vocabulary. Recognizing the key role of energy in defining U.S. national security interests, Seminar 6 took both a wide and deep view of U.S. global energy industries and issues--wide, by studying a cross-section of energy industries, including oil, natural gas, nuclear, and renewables; and deep, by studying the whole chain of energy supply, from extraction through processing, consumer use, and environmental consequences. This report presents the results of this study, including policy implications for national security.

PETROLEUM

Framing the Issues. The continuing demand for oil as a primary energy source is dominated by four major themes: global resource access, maintenance of secure supplies, ever growing environmental regulatory compliance, and pressure for consumer conservation. Due to its relative ease of transportation, availability, and cost, petroleum is one of the most important sources of energy available. It is the single largest contributor to world energy production comprising 37.7% of the world's total. This percentage is projected to remain at about 37% through 2010.

The United States uses about 17 million barrels (MMB) of oil daily which is one-fourth of all petroleum consumed worldwide. Nearly two-thirds of this domestic consumption is used for transportation and this percentage grows approximately 1.5% yearly. By 2010, nearly 90% of all petroleum consumed in the United States will be used for transportation. Future strategies and solutions must address the complexities of this issue.

Reserves. The overwhelming majority of the world's proven oil reserves lie in the Persian Gulf region. Proven reserves are those quantities of petroleum that are known to exist and can be produced with existing technology and in the current economic conditions. Proven reserves can be increased by development of new production technologies or a rise in the price of oil on the world market that makes more expensive production methods economically feasible. Other significant proven reserves lie in Venezuela, Mexico, and the Former Soviet Union. The U.S. has proven petroleum reserves of about 23.5 billion barrels, or 2.2% of the world's total. In addition to proven reserves, the U.S. maintains a strategic petroleum reserve (SPR). Currently this reserve is 592 MMB or about 197 days of supply based on a maximum drawdown rate of 3.1 MMB per day (MMB/D).

Production. In addition to having the largest reserves, Saudi Arabia also leads the world in petroleum production, producing about 14% of the world's daily consumption. Table 1 shows the 10 countries with the largest reserves on the left and the 10 leading petroleum producers on the right.

Table 1
World Reserves by Country

Country	% World Reserves	Country	%World Production
Saudi Arabia	24	Saudi Arabia	14
Former USSR	17	UAE/Kuwait/Qatar(1)	12
Iraq	9	United States	10
Kuwait	8.5	Russia	10
UAE	6	Iran	6
Venezuela	5.8	China	4.8
Iran	5.6	Mexico	4.4
Mexico	4.7	Venezuela	4
Libya	3.5	Nigeria	3.4
China	2.7	United Kingdom(2)	3

(1) includes production figures for Algeria and Gabon (2) proven reserves are approximately 2% of world reserve
(Source: Annual Energy Review 1993)

Consumption. World petroleum consumption, currently dominated by industrialized and developing nations, will continue to rise. Today, the United States tops the list using 25.5% of the world's daily total. Japan (8.1%), Russia (6.4%), Germany (4.3%), China (3.9%), Italy (2.9%), France (2.9%), U.K. (2.7%), Canada (2.5%), and Brazil (2.1%) round out the top 10 petroleum users. As the U.S. economy strengthens and the demand for transportation increases, the highly competitive U.S. retail market for motor fuels (gasoline, diesel, and aviation fuels) will continue to place an increased demand on foreign imports.

Pricing. Crude oil and refined product prices are set by the world market. 1994 saw price per barrel of crude oil drop to almost $12.50, then slowly recover to its present level of about $18. This rise in price corresponds to the economic upturn in the United States and the European Union, which caused world demand to increase in 1994.

Outlook

Short-Term Petroleum Production/Consumption. Continuing demand from economic growth, a slowdown in the rise in non-OPEC production, and the low probability of significant oil exports from Iraq, should cause the current price levels to remain relatively flat over the short-term. Growth in U.S. oil consumption of about 1.5% annually will result in a rise in domestic consumption level of about 0.2 MMB/D in 1995 and 0.3 MMB/D in 1996. Globally, world economies are improving and oil

demand is predicted to reflect a commensurate increase. World oil demand is expected to match the U.S. growth rate of a modest 1.5% through 1996.

Long-Term Petroleum Production/Consumption. By the year 2000, oil production outside the Persian Gulf is forecast to be only about 0.9 Mb/d higher than the 48.4 Mb/d production in 1994. Total non-OPEC production in 2000 is seen only 0.4 MMB/D higher than the 1994 level, with most of this rise coming from countries now producing only minor amounts of oil, and where risks are high. The "rising tide of non-OPEC oil production" forecast by some analysts is mostly a short-term phenomenon that should peak in 1996. In general, the growth in non-Gulf OPEC countries over the 1995-2000 period will be modest as long as current "low" prices stay above the long-run cost of production. By 2010, the world will be increasingly reliant on Gulf-OPEC oil production to satisfy world demand and this implies upward pressure on crude oil prices.

Global Outlook. Proven petroleum reserves will satisfy world demand well into the 21st century, and oil is projected to supply about 37% of the world's energy through the year 2010. Oil consumption will double in the Third World with a growth averaging 6.7% per year. The OPEC producers will be faced with two important decisions in the near future. First, how much oil to produce? By limiting each OPEC country's production, the organization keeps prices high enough to maximize profit per barrel. OPEC will only install as much capacity as they wish to use-price is not a limiting factor. This policy may fall to a more aggressive production plan to increase total revenues for each producing country, particularly if one or more of the member nations suffers an economic downturn. Second, how will OPEC deal with Iraq when sanctions are lifted? Certainly that country will desire to produce as much oil as possible to gain revenue for rebuilding. This will put serious pressure on OPEC production limiting policies.

The Former Soviet Union (FSU) is another area where an increase in production, even at the expense of world prices, may provide much needed revenue. Most experts agree that it will be several years before the stability of the FSU countries is such that they will significantly impact the world oil market through increased production. When this does occur, it will only compound the production problems of OPEC.

Domestic Outlook. U.S. oil production is declining due to exhaustion of certain fields, inability of some companies to produce at a price of $18 per barrel, and increasingly stringent environmental laws. While increased imports from Mexico and Canada will mitigate this decline, OPEC will supply an increasingly larger share of U.S. petroleum imports, which will be required to sustain continued economic growth. The Department of Energy (DOE) anticipates that U.S. oil imports from OPEC will rise from today's 44% to nearly 65% in 2010.

Another challenge to the U.S. petroleum industry will occur around 2000 when the world supply of low-sulfur crude oil peaks. U.S. refinery capacity is already dwindling due to offshore competition and will be faced with high-sulfur crude as its major source for distilling. This high-sulfur crude does not yield as many distillates as the low sulfur variety now being refined in the U. S. While all worldwide refining capacity will be challenged by this change in crude type, the U.S. refining industry will be particularly vulnerable.

Strategy for Survival. Sustained global and domestic economic growth demands energy. The petroleum industry, like the energy industry in general is affected by the following issues: globalization of the market place, continued economic growth, access to existing and future supplies, environmental regulation, and consumer conservation. A successful petroleum strategy must reflect a clear understanding of the supply and consumption patterns within this context. Given our dependence on oil for transportation, the strategy for the future must address the government and industrial issues of the transportation sector.

Regulatory Impact. Current U.S. strategy attempts to emphasize: secure supplies, consumer conservation, and avoidance of unnecessary pollution through strict regulatory mandates and laws. The National Appliance Energy Conservation Act of 1987 (NAECA), the Energy Policy Act of 1992 (EPACT), and the Climate Change Action Plan (CCAP) all contain more stringent efficiency standards and provisions which will significantly impact producer profit and consumer cost. The transportation sector has been subject to such regulations for years. The Corporate Average Fuel Economy standard mandates across-the-board average miles-per-gallon compliance. Additionally, as required by the Clean Air Act Amendments of 1990 (CAAA90), reformulated gasoline is currently required in nine of the most serious ozone non-attainment areas. Renewable oxygenated blending is now required to meet the specifications and standards outlined in CAAA90. Environmental issues are expected to remain at the forefront of U.S. Government policy, particularly as more and more high-sulfur crude is imported.

The U.S. Government has not taxed petroleum to the same extent that the rest of the developed countries have. For example, while U.S. gasoline prices are about half the price of the rest of the developed world, U.S. gasoline taxes are approximately half the rate of these countries. Given the low cost of crude, higher taxes are an attractive source of government revenue. Increased taxes should encourage conservation, discourage consumption, promote the use of alternative fuels, and fund increased government and industry investment in R&D.

It is unlikely that the current U.S. embargo of Iraq's oil will be lifted in the immediate future. With the majority of world reserves residing within the Persian Gulf, and new production fields inaccessible at today's oil prices, the current supply and demand

forces are expected to ensure moderate growth in oil prices. This outlook may become brighter with the use of three-dimensional modeling and horizontal drilling technologies.

Unfortunately, this policy lacks a clear long-term vision for energy. The increased dependence on Persian Gulf oil, with potential supply disruptions and volatile oil prices, continues to generate uncertainty.

Industry Issues. The current strategy pursued by the petroleum industry is best characterized as global. Years of declining American refinery capacity and ever-increasing environmental standards within U.S. borders, forces companies to invest in drilling and production ventures outside the U.S., i.e., wherever resources and reasonable profit margins can be found.

The global market is just one of several major issues facing the industry. Government actions supporting deregulation, the removal of artificial incentives, price controls, import quotas, etc., allow free market forces to operate. However, environmental laws, reformulated gasolines for ozone non-attainment metropolitan areas, refinery emission standards, and transitions to high-sulphur crude combine to increase prices to consumers and decrease profits for the industry.

The complex nature of industrial policy issues can also be seen in the capital investment decline of the last several years. The U.S. regulatory structure has created little incentive to invest capital in research and development programs, and has also prevented off-shore production near the U.S. coast.

Recommendations. Our fundamental premise states that oil is a key ingredient for economic growth. Political and economic stability requires an uninterrupted free market supply, including the ability to distribute available oil and the ability to quickly transition to other fuels if required. Historically, supply disruptions created a bow-wave of negative reactions highlighted by increased consumer prices, increased unemployment, and a decline in gross domestic product. The SPR may be able to ameliorate price shock, but only on a small and limited scale. Production access to underdeveloped oil resources will take time and therefore are not available for short-term stabilization. How, when and where these reserves will be accessed demands planning and preparation today. Conservation must be designed to reduce imported oil, not just the overall use of oil. Given budget constraints, there are currently no plans for oil acquisition or capacity expansion for the U.S. SPR beyond today's levels. Additionally, there are no contingency plans to expand beyond a drawdown rate of 3.1 MMB/D.

The last two decades of world oil prices reflect market forces and policy actions involving both exporters and importers. Assuming the U.S. do not encounter any wars, embargoes, natural catastrophes, or major new discoveries, oil prices should

slowly rise. However, these events should not be considered impossible, and Persian Gulf dependence should be countered with a balanced energy policy which guards against uncertainty by doubling SPR capacity, investing in R&D, streamlining regulations when possible, and rewarding U.S. companies with incentives for quality production within American borders and near the U.S. coastline. Continued and growing oil dependence upon foreign sources will not enhance American economic strength and prosperity.

COAL

History. Coal has been America's major energy source for most of its history and continues today as the primary fuel for the electric utility industry. From the mid 1800s until the 1940s, when petroleum first surpassed it as the nation's principal energy source, coal powered the factories, the steel mills, and the railroads that transformed America from an agricultural to an industrialized nation.

By the 1950s, overall coal consumption declined as the nation turned increasingly to natural gas and oil for home heating, and to the diesel engine for rail transportation. At the same time, increased environmental regulation and growing government, utility, and public interest in nuclear power to generate electricity further reduced the demand for coal. Nevertheless, the electric utility industry continues to rely on coal as an abundant, cost-effective fuel resource. In 1961, coal became the major fuel used by electric utilities, a trend that continues today. Much of coal's resurgence during the 70s was due to the 1973 Arab oil embargo-the recognition that coal supply was unaffected by the politics and instabilities of the Middle East. Coal's reliability of supply and lower cost contrasted sharply with the relatively higher prices of petroleum and natural gas. As a result, electric utilities turned back to coal for new baseload power generation beginning in the 70s.

Structure. Coal production is a capital-intensive, highly-regulated (environmental and safety) industry representing the largest single source of U.S. energy production (about one-third of the nation's total energy production). In 1994, 26 states produced over one billion tons of coal. Wyoming was the largest producer with 231 million tons, followed by Kentucky (159 million tons) and West Virginia (157 million tons). Of the over one billion tons produced in 1994, 43% was mined in the Appalachian region, 18% in the interior region, and 39% in the western region.

The number of active coal mines has declined substantially over the last decade-to about 2475 active in 1993. In general, this decrease was due to the closure of unprofitable mines and a trend toward fewer but larger mines, particularly in the west. In 1993, 2.3% of all active mines each produced over three million tons of coal. Coal production from these mines represented 49% of the national total. The nation's largest coal mine, Black Thunder, located in Campbell County, WY, produced over 34 million tons of coal in 1993. There has been a similar decline in the number of coal

companies over the years. Lower coal prices, higher production costs, and mergers have resulted in fewer, but larger, more diversified coal companies. At the close of 1993, 63 major companies operated coal mines in the U.S, with no one producer controlling more than 10% of the coal market. These consolidations are expected to continue in the future.

Coal prices have steadily declined since 1982, when utility coal sold for $27.14 per ton. In 1993, the average price was $19.85. Lower prices were due to increased productivity and output, particularly in the western surface mines. Productivity has increased 2.4 times since 1980 and has quadrupled since the 1950s. One of the major technological innovations for underground mining is the longwall miner, where a drum is pulled mechanically back and forth across a face of coal that is up to 800 feet long. This method currently accounts for 31% of underground coal production.

Reserves. The United States possesses 21.7% of the world's bituminous and anthracite coal reserves, the largest amount of any country. Ninety percent of the fossil fuel energy reserves of the United States is coal. If measured in terms of oil equivalency, these supplies are greater than either the world oil or natural gas reserves. The United States' recoverable coal reserves, which are defined as those that can be recovered or mined economically from demonstrated reserves, are approximately 285 billion tons. These reserves are divided nearly evenly across the country. Taking into account the current rate of use, U.S. coal will last more than 250 years.

Price Structure. For utilities east of the Mississippi, there are four factors to consider when determining the "best" coal to buy: 1) minemouth price, ranging from $7 per ton for Wyoming surface mining coal to $27 per ton for Appalachian coal (mostly underground mining); 2) transportation costs, which vary from $3 per ton for Appalachian coal to $18 a ton to bring Wyoming coal to the eastern utilities; 3) energy coefficient of the different types of coal (Appalachian coal produces approximately 13,000 BTUs per pound, while western coal produces about 8,500 BTUs per pound); and, 4) sulfur content (Appalachian coal contains 2.5% sulfur versus western coal which contains 0.5% sulfur). The decision to buy higher-sulfur coal from eastern producers will be significantly affected by the reduced emission requirements which go into effect in 2000. But for western utilities the decision will remain the same-continue to buy western coal.

Regulatory Issues. Coal's impact on our environment has resulted in both federal and state legislation which affects the industry's short- and long-term growth strategies. The three environmental concerns affecting coal are water quality, land reclamation, and clean air.

Water Quality. In an attempt to prevent damage to ground and surface waters, the Federal Government enacted the Surface Mining Control and Reclamation Act (SMCRA) and the Clean Water Act. Water discharged from mining operations must

meet stringent quality standards. Areas of concern are acid mine drainage control, protection of the ground water, and prevention of surface water sedimentation.

Land Reclamation. The SMCRA also regulates the reclamation of lands that would be or have been subjected to mining operations. Its purpose is to return the land to a condition as least as good as the original condition. Companies must post a bond (as high as $10,000 per acre) which will not be returned until the site has been restored to an approved state or condition. Additionally, coal producers are required to contribute to the Abandoned Mine Fund through 2004 to reclaim old surface mines previously closed.

Clean Air. The Clear Air Act (CAA) of 1970 set standards for the maximum allowable emissions of pollutants (sulfur dioxide and airborne particulates) dischargeable from coal-fired plants. With the CAAA90, emission controls tightened further and specific requirements for reducing nitrogen oxide were added. The new requirements were for an additional 10 million ton reduction in sulfur dioxide emissions from 1980 levels by the year 2000 and establishment of an operating permit program to ensure compliance. Phase I (implemented through 1999) requires the 110 largest sulfur-emitting power plants to emit an average of 2.5 pounds of sulfur dioxide per million BTU of heat input. A further reduction to 1.2 pounds in Phase II begins in the year 2000. Additionally, the 1993 CCAP commits net U.S. greenhouse gas emissions to 1990 levels by the year 2000.

Safety. A strong safety and health program exists in the mining industry. The Federal Mine Safety and Health Administration has strict regulations that have lowered accidents to 9 per 200,000 employee hours and reduced fatalites toarate of 0.04 per 200,000 employee hours. Safety and health reporting requirements have focused on protecting miners from respirable coal mine dust, methane gas, noise, toxic materials, and harmful physical agents. Additionally, coal producers contribute $1.10 for every ton of underground coal mined and $0.55 for every ton of surface coal mined into the Black Lung Disability Trust Fund.

Government and Industry Strategy. Environmental legislation, transportation costs, safety, and coal mining productivity have important ramifications for the future of the coal mining industry. Government, the coal mining industry, and the electricity generation industry must develop a coordinated strategy to ensure that our most abundant energy resource is utilized in its most productive and efficient manner.

Beginning in 1986, the Federal Government and industry formed a cost-sharing partnership to develop solutions to the environmental concerns facing the nation's coal industry. The result was the Clean Coal Technology Program with its goal of using the best and most innovative technology from world-wide sources to improve the environmental impact of coal. To date, 45 projects in 21 states have been started. The technologies in development will allow the expansion of coal-fueled electric power

generation plants, and assist industry in meeting environmental standards and in developing clean liquid fuels from coal. The clean coal framework breaks down into four technology-oriented groups: pre-combustion coal cleaning, combustion and fluidized-bed processes, post-combustion clean-up of flue-gases, and advanced coal conversion technologies (to gas or liquid). These technological advances promise to deliver a greater than 50% increase in power generation efficiency, which will lower electricity costs and reduce the emission of pollutants.

Outlook. Coal will continue to be America's leading energy resource for the foreseeable future-its market share of total energy usage will actually increase through the year 2010. Coal maintains its cost advantage over both oil and natural gas and will continue to produce the bulk of electricity in the U.S. Although natural gas in general is the choice for new power generation, coal will remain the choice for new baseload for the next 15 years. The demand for coking coal in the industrial sector will continue to decline as the steel industry switches to alternate energy sources to operate their furnaces. A higher consumption forecast for steam coal results from increased use in the chemical and food-processing industries and the increased use of coal for cogeneration. Coal use in the residential and commercial sectors is negligible and will remain so. Worldwide coal demand is expected to grow, with U.S. exports of steam coal to Europe being a major market as coal continues to be a trade surplus resource for the United States.

NATURAL GAS

Industry Structure

Segments. The natural gas industry in the United States has three distinct segments, with a fourth emerging. The first is exploration and production, including withdrawal from gas wells and oil wells and processing. This segment is composed of thousands of small, independent producers and most major oil companies. The second is transportation, which is almost synonymous with pipeline transmission. While there are over 200 pipeline companies, the top 10 operate over 50% of the pipeline mileage. The third segment is composed of nearly 1,300 local distribution companies (LDCs), roughly two-thirds of which are owned by municipal governments. A new entity in the industry, natural gas marketers, constitutes the fourth segment. These companies provide the service of matching buyers to sellers of gas and arranging transportation.

Consumption. Natural gas has several distinct markets. Historically, industrial customers are the largest consuming sector, accounting for about 7,942 billion cubic feet (bcf) or 42% of all deliveries. Residential consumption is the second largest market- about 4,957 bcf or 26% of demand. The third group of buyers are electric utilities, who use about 2,682 bcf or 16% of total deliveries. Finally, the commercial sector of gas demand a constitutes roughly 2,912 bcf or 16% of annual consumption.

Exploration and Production. After a decade of excess production capacity, gas supplies and demand achieved greater balance in 1993. In December 1985, more than 30% of U.S. natural gas production capacity was idle. By December 1993, idle capacity had decreased to a more reasonable 17%. Rising gas prices in 1992 signaled to producers to begin new drilling which continued into the first half of 1993, surpassing oil well completions for the first time.

Transmission and Storage. Historically, this segment of the industry has been viewed as a natural monopoly and has been highly regulated with the goal of obtaining natural gas supplies and providing those supplies on demand primarily to LDCs. Today, this segment is in the midst of the most significant restructuring in its history as it adjust to the more competitive, post-Federal Energy Regulatory Commission (FERC) Order 636 issued in April 1992. Competition has been introduced in the gas transmission industry through establishment of secondary markets in pipeline transportation which permits pipeline company customers to trade capacity rights among themselves.

Imports and Exports. Pipeline imports of natural gas, primarily from Canada, continue to grow, reaching 11% of gas consumption in 1993. Expectations that Mexico would become a significant purchaser of U.S. natural gas have not materialized in recent years due to the slumping Mexican economy. In fact, Mexico exported natural gas to the U.S. in 1993 for the first time in nine years. The North American gas industry is becoming increasingly integrated with an extensive import export trade. Elsewhere, U.S. imports of liquefied natural gas (LNG) from Algeria have been increasing steadily while exports of LNG to Japan have remained relatively constant in recent years.

Pricing. The price paid by the end-user includes the costs of the many transactions necessary to bring natural gas from the producing field to the burner-tip. Table 2 compares the 1984 to 1993 component cost, showing that the increasingly competitive market has led to lower cost of supplies and lower cost of getting gas to the consumer.

Table 2
Components of Natural Gas End-Use Prices
(1993 dollars per thousand cubic feet)

Price component	1984	1993
Wellhead price	2.73	2.02
Markup to citygate	1.67	1.19
LDC distribution markup		
Residential	2.96	2.98
Commercial	2.18	1.97
End-use price		
Residential	8.35	719
Commercial	7.57	5.18

(Source: Annual Energy Outlook 1995, EIA)

Natural Gas Outlook

Supply and reserves. The current consumption of natural gas appears sustainable with proved reserves within the United States (gas that can be readily produced) estimated at 165 trillion cubic feet, which amounts to roughly 10 years production at current rates. For the long term, there are substantial gas reserves in Alaska and Canadian frontier regions which depend on construction of gas pipelines. At current prices, pipeline construction is not practical and deliveries of this gas are not expected prior to 2010. Even longer term, the U.S. Geological Survey speculates that as much as 3,200 trillion cubic feet (tcf) of gas (roughly 200 years production at current levels), may be present at depths between 14,000 and 22,000 feet. Deep-well drilling is too high cost to include this in the currently recoverable base, but new technological advancements may eventually open this frontier for exploration. Breakthroughs in the technology of exploration, extraction, or use of natural gas could lower the relative cost of natural gas and make it even more competitive with coal for electricity production or oil for use in vehicles. New developments in gas-fired space cooling may increase commercial usage.

Consumption and Production. Natural gas production within the U.S. is forecast to increase at an average rate of 0.8% between 1993 and 2020, meeting more than half the growth in demand. By 2010, natural gas consumption is expected to follow closely behind coal consumption, representing about 25% of the nation's total primary energy use versus about 32% for coal. Market expansion is driven primarily by increased electricity demand and requirements for alternative-fuel vehicles. Residential and commercial consumption is likely to remain relatively flat due to improvements in efficiency. Imports, primarily from Canada, will increase to satisfy the additional demand. Gas-fired generation by utilities, non-utilities, and cogenerators is forecast to overtake nuclear power as the nation's second source of electricity (behind coal) by 2010, accounting for roughly 11% of energy inputs in electricity generation. While gas-fired generation of electricity is more flexible than coal, has lower initial capital costs, is more efficient, and has strong environmental advantages, coal's low cost makes it preferred for baseload for the next 15 years.

International Opportunities. Pressures are building worldwide to increase consumption of natural gas, although cost and transportation limitations continue to prevent intensive use. DOE predicts natural gas is likely to rival coal as the runner-up to oil in

global importance during the next 15 years. Highest growth rates for natural gas consumption are expected to occur in the developing countries of the world.

Price Outlook. DOE currently forecasts natural gas prices will increase slowly in future years with wellhead prices reaching $3.39 per tcf by 2010. Delivered prices are expected to rise even more slowly than wellhead prices due to declining costs of transmission and distribution. The differences in end-use prices among consuming sectors are likely to widen in the short-term as industrial and electric utility companies increasingly bypass local distributors to obtain service directly from interstate pipeline companies or producers.

Regulatory Impact. The natural gas industry has undergone dramatic changes over the last decade as a result of Federal Government deregulation and industry restructuring. In addition, natural gas as a relatively environmentally benign energy source benefits from the more stringent environmental requirements impacting other fossil fuels.

FERC orders enacted over the last decade have promoted market competition by deregulating wellhead prices and restructuring the natural gas interstate pipeline industry. FERC Order 636 (effective 11/93), unbundled the interstate natural gas pipeline companies from the sales services and allows pipeline companies to sell gas at market-based rates. A 1994 ruling by FERC has set the precedent for further unbundling of the pipeline companies from the gathering end of the industry. With the decoupling of the pipeline companies from the gathering business, they will be forced to become more competitive and offer innovative services to producers, marketers and LDCs. But it also points to the need for states and LDCs to consider restructuring distribution to achieve more competitive pricing.

The impact of Federal deregulation is that costs are no longer driven by the transferred costs of placing and maintaining physical assets in service, but rather by competition. Along with industry restructuring, customers can now purchase natural gas directly from the producers and arrange for pipeline and distribution companies to deliver for a fee. All of this has led to additional gas production, lower prices, and consequently, increased price volatility. Producers now sell gas openly on the stock market and find themselves increasingly exposed to market forces and unstable prices. Further, with the Federal regulators taking a light-handed approach to regulation, regulation of services will be left more to the state public utility commissions.

The CAAA90 presents significant opportunities for growth of the natural gas industry. These amendments require states to impose operating permit requirements on hazardous air pollutant discharges, including new requirements on acid rain, and impact the most on oil and coal power generation. Additionally, promoting the use of natural gas is a key part of the strategy to implement this CCAP for reduction of

greenhouse gases. Considered together, all of these regulatory initiatives promote natural gas as a clean fuel alternative.

A major issue facing both the pipeline industry and regulators is the safety of the pipeline infrastructure. Much of the pipeline network predates the 1972 peak year in construction and is nearing the end of its operating lifetime. It's estimated that costs to refurbish and replace the network could approach $1.7 billion in 1991 dollars over the next 15 years. It's also anticipated that the gas pipeline explosion last year in New Jersey could prompt greater rulemaking attention on pipeline safety issues.

Government and Industry Strategies. Federal deregulation of the natural gas industry, EPACT, the CAAA90, and the policies of the current administration have substantial implications for the gas industry. Government policies under the last two administrations and the current administration have promoted an open market and more viable natural gas industry, largely through government deregulation and through the EPACT. The government's policy is basically to allow the market to develop with as few regulatory restrictions as possible and allow more flexibility in gas movement. In addition, the Clinton Administration has de-emphasized nuclear energy promoted by the last administration in favor of natural gas, coal gasification, and renewables. Natural gas has also benefited from the Administration's CCAP and the Domestic Natural Gas and Oil Initiative, both announced in 1993. While CCAP promotes summer use of natural gas in lieu of coal and oil and for industrial facilities, provides government cost sharing in the commercialization of high-efficiency gas technologies, and promotes expansion of the Natural Gas Star Program to reduce methane emissions in the natural gas industry, the Domestic Natural Gas and Oil Initiative offers special help to small exploration and production companies, such as by improved dissemination of new fracture and extraction technologies.

EPACT specifically promotes the use of natural gas in the transportation sector and in electricity generation by NUGs, and encourages increased growth in gas-powered electric generation plants. Both EPACT and CAAA90 promote alternative transportation fuel use initiatives. It's estimated that 700K NG vehicles will be operating in government and private and commercial fleets by the year 2000 in U.S. cities especially in CA, just to meet EPACT and the CAA. However, given the limitations of natural gas as a transportation fuel, it is unlikely that natural gas fuel vehicles will capture a significant part of transportation market share.

Together, government and industry funds about $100 million annually for R&D for new gas exploration technologies. Areas of research include three dimensional seismic work to better evaluate the extent of natural gas reserves, horizontal drilling to allow extraction of a higher proportion of a reservoir's contents, and deepwater drilling technology.

On the other hand, industry strategy is focused on positioning themselves in a market-driven environment, smoothing out demand patterns and improving year-round reliability. Dramatic restructuring of the industry will continue in the future. Should crude petroleum prices remain sluggish over the medium-term, end users capable of so doing may want to shift away from natural gas. This would reduce the incentive to explore for new supplies of gas or exploit those sources (including coalbed methane or gas from "tight sands"). Pipeline companies must invest in maintenance of existing facilities and build new pipelines (including connections with the Canadian network) to respond to changing demand patterns. With industry unbundling, LDCs will need to develop increasingly sophisticated purchasing and storage capabilities.

Policy Issues/Recommendations. Over the last decade, the Federal Government has taken positive steps to promote natural gas industry efficiency, reduce the regulatory uncertainty, and, thus, promote free market competition. However, should natural gas supplies tighten or prices increase significantly, there could be a groundswell of support for renewed Federal or state and local regulation. Government should resist the temptation to influence the market through regulation. Additionally, major opportunities for growth lie in the electrical generation sector. The major obstacles are: competition from other energy sources, such as coal gasification and alternative energies; uncertainty concerning whether price will remain competitive with other energy sources; and uncertainty regarding demand side requirements of the electrical sector. Probably the most serious of these are the price and demand uncertainties. However, should demand increase faster than expected and supplies tighten, the Administration and industry should revisit the current policy of denying or restricting offshore drilling.

ELECTRICITY

Industry Structure. Until recently, electric utilities were vertically integrated, both producing and selling power. The electric power industry in the U.S. was changed substantially by the 1978 Public Utilities Regulatory Policy Act (PURPA), which greatly increased the contribution of NUGs to total electricity availability. NUGs currently account for half of all additions to capacity and this trend will continue. Further changes will take place when EPACT comes into force, strengthening controls on emissions and realigning the cost efficiencies of different sources of energy.

The U.S. electric power industry is increasingly involved in international power generation issues for both "push" and "pull" reasons. The industry is being driven by the slowing growth of demand in the U.S. and the increasing effect of U.S. environmental regulations to seek overseas markets. Deregulation, which will permit further segmentation of the market, challenges the future of the electricity utility as a monolith. This trend will encourage some producers to diversify and act as technical advisors abroad while retaining their market share in the United States. The industry is

simultaneously being attracted abroad by the growing energy demand in most developing countries where projected growth promises a greater profit.

Industry Outlook. The demand for electricity has grown steadily for decades, but has gradually slowed since the 1960s, when it reached annual growth rates of 7% per year. Electricity demand will lag somewhat behind GDP growth, because of increasing efficiency in its use. Within these projections, the greatest growth will be in electricity use by end users. The U.S. economy consumed 9.43 quadrillion (quads) BTU in 1992 and is projected to consume 11.86 quads in 2010, an average annual growth rate of 1.1%. Worldwide electricity demand will grow more quickly than in the U.S., although worldwide demand in general is slowing (2.9% between 1990 and 2015 vs. 4.7% between 1975 and 1990). Demand for electricity will drive economic growth in Asia and Latin America where American firms stand to meet many new opportunities. At present, the U.S. produces approximately 28% of world electricity. Four countries, the U.S., Russia, China, and Japan, produce over half of the world's electricity. U.S. electricity prices are predicted to fall 1% between 1994 and 2005 and 0.2% between 2005 and 2015. The industry expects a temporary drop in prices due to deregulation of natural gas distribution and sales, coupled with the current lower price of coal.

Policy Issues. The key policy issues in the electricity sector are regulatory and environmental. Of these two, environmental issues are more important. In fact, at the current state of technology, the key determinant of electricity price is the cost imposed by environmental regulation. The key environmental issue is emissions control. In the area of privatization and industry structure, there are limited options for further increases in competition, and analysts are divided about whether this is desirable. Future developments in the area of privatization should be guided by the experiences of Great Britain during their 1990/91 privatization transition. "Generation and distribution activities were separated with the creation of two main generators. . .and 12 public electricity suppliers responsible for distribution. A competitive market now exists for all consumers requiring over 100KW; competition should be extended to all consumers by 1998." (McGraw-Hill's global electric power industry forecast, Electric World, January 1995.)

NUCLEAR

History. In many respects the commercial "atomic age" began on December 20, 1951 when an experimental nuclear plant, the Experimental Breeder Reactor I, generated enough electricity to light four 200-watt light bulbs. This successful harnessing of nuclear fission energy, the heat released when the nucleus of an atom splits, offered the promise of providing abundant electricity at relatively low cost and providing power without the negative environmental effects of burning fossil fuels. By the early 1970s, nuclear power plants were as popular as coal-fired power plants for utility companies that were planning new plants.

Since the mid-1970s, the nuclear industry has gone through a period of stagnation and is now in clear decline in most parts of the world. The events that triggered this include the 1973 Mideast oil embargo, which caused an overall slowdown of the global economy and a wave of energy conservation which reduced the rate of growth of energy consumption and, therefore, the need for new power plants of any kind; and the 1979 Three Mile Island (TMI) and 1986 Chernobyl accidents. These two nuclear plant accidents differed significantly. The containment structure operated successfully at TMI and prevented any appreciable release, while at Chernobyl, their confinement system failed resulting in massive contamination over a wide area. In spite of these differences, the incidents had a catastrophic effect on the nuclear industry. The U.S. public reacted with fear and wholesale rejection of nuclear power. The U.S. Government reaction was to address safety through increased regulation which has significantly increased both investment and operating costs.

The threefold impact of these events-decreased market growth, public fear, and tremendous cost increases-has brought the U.S. nuclear industry to its knees. The domestic outlook for industry growth is bleak at best. However, worldwide, there are a few strong markets. Most of Western Europe, with the notable exception of France, has turned its back on nuclear energy for many of the same reasons as those confronting the U.S. industry. Eastern Europe's industry is also a declining market largely because of slow economic growth and safety concerns. The Far East appears to be the one high-growth market with India, South Korea, and Japan embarked on particularly aggressive nuclear construction programs.

Industry Structure. The nuclear industry in the U.S. is not vertically integrated; no companies operate in all aspects of the nuclear fuel cycle. The cycle can be characterized in three parts: the front end which includes exploration, mining, milling, conversion, enrichment, and fabrication; commercial use which is comprised of reactor processing and conversion into the end product (electricity); and, finally, the back end which includes interim storage, reprocessing, and waste disposal.

For the front end of the cycle, there are oligopolies in both conversion and enrichment of uranium. The second phase of the nuclear fuel cycle is characterized by regional utility monopolies which are highly regulated. Consumers of electricity, regardless of the source, are "locked in" to the regional supplier, such as Virginia Power in the Northern Virginia region. The back end of the fuel cycle, (i.e., spent fuel) is the responsibility of the Federal Government under the Nuclear Waste Policy Act of 1982. It established 1998 as a target year for the government to begin accepting spent fuel from utilities. The target has since slipped to 2010, at the earliest. The approved site, Yucca Mountain, Nevada, has encountered severe scientific and political uncertainties in efforts to begin construction and operation.

Nuclear Energy Sector Outlook. In 1993, 55% of electrical power production was fueled by coal; nuclear was second in importance providing approximately 14%. The

absolute amount of nuclear power used for electricity production is predicted to remain more or less constant through 2010, but it will comprise a decreasing share as total consumption increases.

At the end of 1993, the U.S. had 109 nuclear reactors on line capable of producing a total of 99 gigawatts (GW). Of these, 10% will reach the end of their projected 40-year life by 2010, 50% by 2020, and the remainder by 2030. Only one new plant, the Tennessee Valley Authority's Watts Bar I plant, is expected to begin operation in the near future. Both the short- and long-term outlook will continue much as the trend since 1979. That is public and political opposition will continue to be strong and will actively discourage additional investments and may result in older plant closings as current licenses expire. It is highly unlikely that new plants will be constructed.

In spite of public fears and strong political opposition in the U.S., nuclear power possesses some advantages over fossil fuels. First, nuclear power is less environmentally harmful as it does not produce acid rain or carbon dioxide-induced climate change. It therefore responds more favorably to tougher emission standards. Second, there is extensive current physical capacity in place. As a practical matter, replacing existing nuclear-fueled electricity plants with new plants using other fuels would be extremely expensive. Therefore, much of the existing nuclear infrastructure is likely to be maintained as long as it is feasible to do so. And third, uranium is a relatively efficient, abundant, and inexpensive fuel. On the other hand, countries such as France are moving forward with nuclear power, both in terms of new plant construction and in terms of operating a closed fuel cycle system.

Price Outlook. As of 1990, it was estimated that a nuclear plant would cost approximately $3,000 kilowatt (kw) to build versus $1,600/KW for a coal-fired plant. A one million KW nuclear plant, therefore, would cost $3 billion versus $1.6 billion for coal. Pressures associated with raising that much capital, paying the carrying charges, and seeking increases in electric rates to pay for these costs make new investments in nuclear plants unlikely. However, two standard next-generation reactor designs have been approved by the Nuclear Regulatory Commission (NRC). These could significantly reduce plant licensing and construction time and cost.

Additionally, currently operating nuclear plants have now become approximately 10% more expensive than coal fired plants to operate and maintain ($22 versus $20 per MWh). Operating and maintenance costs are high for several reasons: low productivity, plant outages and regulatory burden.

Waste Disposal. There are two means of disposal of spent uranium fuel: direct storage and reprocessing. For commercial fuels, France and United Kingdom are the leaders. Additionally, most nuclear countries have chosen to reprocess spent uranium for re-use rather than direct disposal. To date, only the U.S. and Canada have chosen to rely solely on direct disposal of spent fuel. The continuing delays in the

projected opening of the Yucca Mountain underground permanent storage site is a tremendous problem. By 2010, half of all nuclear power plants will run out of spent fuel storage space and be forced to shut down if alternatives are not found. Leap-ahead technologies, most notably nuclear fusion, would reduce or eliminate waste, thus providing a clean source of energy. This particular technology, unfortunately, is not expected to be commercially viable until approximately 2050. For low-level nuclear waste, several disposal alternatives are available that are expected to accommodate demand.

Government and Industry Strategies. Since TMI, the U.S. Government's explicit strategy towards commercial nuclear power has been to increase regulation of existing operations and stiffen requirements for any new investments. In addition, as part of the EPACT, an Integrated Resource Plan must be developed to prove that any proposed new nuclear plant is less costly than repowering an existing plant, building a fossil fuel plant, or buying electrical power. This has resulted in a defacto policy of discouraging investment and, if unchanged, will eventually kill American nuclear power.

Even if the nuclear industry were able to change public perception of risk with current technology, the American nuclear industry would still face a bleak future because it is uneconomical. In order to be competitive, several aspects must be improved, including: regulatory framework; worker productivity; and changes in Public Utility Commission financing terms. One of the most important changes would include changing the role of the NRC. A recent evaluation by the industry concluded that the NRC's regulatory process distracts licensee management, erodes public trust in nuclear power, and is pricing nuclear power out of the competitive energy market place.

Global Concerns. The Chernobyl accident proved that radioactive contamination knows no borders. The incident captured worldwide public attention. The industry has been unable to overcome this barrier of public perception and has not been able to mitigate the negativism by communicating the technical differences among plant designs, quality of management, and relative safety risks. The public is not receptive to the fact that a repetition of a Chernobyl-like incident is virtually impossible in the U.S. and Western European-designed reactors. Despite this, strong international oversight such as through the International Atomic Energy Agency (IAEA) is needed to avoid a future Chernobyl in other areas of the world which employ Russian RBMK reactors.

Recommendations. By the year 2050, additional baseload capacity will be required to replace the decommissioned nuclear plants. This will mean alternate sources of fuel will be needed. The current state of scientific knowledge indicates that nuclear fusion is a front runner as a clean, inexpensive, and safe alternative. In order to be have the technology ready to use when it will be needed, R&D in nuclear energy must

continue. Public opposition can change over the long term as the reality of the finite limits of fossil fuel hits home. It could change more quickly if price increases in fossil fuels suddenly make them too expensive for generation of electricity.

RENEWABLES

Industry Structure and Outlook. Renewable energy resources-solar power from the sun, wind power, hydro power from rivers and oceans, geothermal power from the heat of the earth, and biomass fuels derived from wood and plant matter-are an inexhaustible source of energy that can provide heat and generate electricity. Interest in renewable energy sources was awakened due to the 1970s oil shocks, but died in the face of low energy prices during the 1980s. The Gulf War, increased environmental awareness, and technological advancements have served to reawaken America's interest in renewable energy resources. The renewable energy industry is tiny when compared to the multinational corporations and giant utilities that dominate the energy industry in the United States. While some major corporations, such as Amoco, have dabbled in the renewable energy business, the industry is populated by small entrepreneurial firms, especially in the solar, wind, and geothermal arenas. Revenues at America's 800-odd renewable firms grew 16% a year between 1989 and 1992 to $2.2 billion. This trend appears to be continuing. Renewable firms have flourished when tax incentives, electricity demands, and public policies have combined to make them competitive.

In 1993, renewable energy accounted for only 8% of the total energy consumed in the U.S., 6.6 of 87 Quads. Approximately 36% of the 87 quads was for electricity production, of which 12% was from renewable energy sources. Despite the increasing demand for safe, clean energy sources, two economic reasons have precluded the extensive growth in the renewable energy sector. Fossil fuels have remained inexpensive, and an extensive up-front capital investment is required in the renewable industry. The current energy infrastructure does not provide an incentive for producers to venture into renewable energy areas.

Performance

Solar/Thermal. Solar power represented only a tiny amount, 340 megawatts (MW), of the U.S. electric capability in 1993. However, technology advances in this area continue to offer tremendous opportunities. Trough-electric solar power is by far the most commercialized type of solar power in use today. The major challenge is reducing the O&M costs which represent about 25% of the electricity cost. Newer plants are projected to operate at 10-14% annual efficiency and produce electricity for about $0.08-$0.14/KWh. The most significant environmental impact is the land requirement. Two additional solar energy types, power towers and dish/Sterling will contribute to lower solar energy costs over the next five years (in the $0.06-$0.11/KWh range). In addition, power towers using molten salt as a thermal energy

storage medium provide the capability to generate electricity at night or when it is cloudy.

Photo Voltaics (PV). DOE recently announced a three-year government-industry partnership to produce a new thin-film solar technology expected to reduce the cost for PV electricity from \$0.25-\$0.50/KWh to \$0.12-\$0.16/KWh. While still expensive compared to fossil fuel and other renewable energy sources, off-grid PV applications will increase in remote locations where delivery costs for utility power are high. In addition, lower-cost PV generation could be utilized in the future for grid-connected multimegawatt central station PV plants, end-of-transmission-line peaking stations, or groups of rooftop PV units.

Geothermal. Exploitable geothermal resources (hot water and steam) are primarily limited to the western United States. Current capacity of about 2,960 MW will probably not grow substantially without gains in R&D. Potential output is often limited by hot water and steam that can be trapped economically. Development of other production means such as the "hot dry rocks" technology should greatly extend the geographical areas in which geothermal energy might be useful. Reductions in drilling costs as well as access to water rights will also benefit the industry.

Wind. Wind power is the fastest growing renewable energy source. Wind currently produces close to 1,800 MW of electricity, mostly in California. However, the amount of wind-produced electricity is increasing, and additional areas from New England to the Great Plains are turning to wind as a supplemental electrical production source. One reason for this growth is the substantial technological advances in recent years. More efficient turbines and wind mills have helped to lower the price for wind produced electricity from \$0.25/KWh in 1981 to a competitive \$0.05-\$0.08/KWh today. Additional technological advances currently under development should drop costs even lower. Key challenges to the wind power industry include the variable nature of wind energy, the lack of storage capability, and wind farm siting. Unfortunately, many windy locations are far from electricity demand centers.

Hydropower. Hydroelectric power has been a mainstay of America's electrical energy grid since the New Deal. In 1993, almost 78 gigawatts (GW) of hydropower was used in electricity production, 10% of the total U.S. production. However, most economical sites have already been exploited, and hydropower has a negative environmental impact on rivers and fisheries. Therefore, little new capacity will be forthcoming, and some current capacity may be lost. Any additional growth will come from hydroelectric turbine repowering. Hydro power costs \$0.04 - \$0.07 per KWh.

Biomass. Biomass is a broad category of renewable energy that accounted for over 3.5% of the energy consumed in the U.S. in 1993. Biomass fuels include wood; municipal solid waste (MSW); wood, agricultural, and manufacturing waste products; and alcohol fuels. In 1993, 32% of renewable energy consumed was from biomass

fuels. Biomass fuels have both positive and negative environmental attributes. While burning biomass fuels does not contribute to sulphur-related acid rain, some cities have instituted wood burning restrictions to limit smog. In addition, MSW burning requires scrubbers to reduce emitting unwanted toxic substances in the air. Biomass use for electricity generation will remain limited unless a dedicated biomass crop close to generation points is produced and conversion technologies are improved. Issues concerning MSW landfill policies, the ability to effectively clean MSW of toxic pollutants, and community resistance to locating MSW plants in neighborhoods must also be resolved.

Outlook. In 1993, renewable energy supplied less than 8% of the total energy consumed, far short of the lofty goal of around 20% by the year 2000 set by President Carter in the late 1970s. The cost to generate one Kwh of power using renewable sources is now beginning to approach the generation costs of using fossil fuels. As new technologies continue to drive down renewable energy costs, as instability in the world oil markets drives up the cost of fossil fuels, or as state and federal policies are revised to reflect current environmental and economic realities, renewable energy sources should gain market share.

DOE predicts that the total consumption of energy from renewable sources may increase by 36% between 1993 and 2010, while energy consumption from all sources may increase by only 20%. The use of wind power may increase eight fold, making it the renewable energy source with the greatest growth potential. Still, renewable energy consumption will only represent 8.6% of the total energy consumed in 2010 according to the DOE prediction. This is only 1% more than the percentage of renewable energy consumed in 1993. Renewable energy advocates dispute the DOE predictions, but unless substantial changes are made in government policies, the method of pricing energy costs is changed to include externalities, or another energy crisis occurs, a large increase above the DOE prediction is unlikely.

Government and Industry Strategy. American utility companies must be concerned with the age of their existing facilities, as well as with the pollution output of those facilities. By the year 2000, the average power plant will be 43 years old, and in the next 10 years, roughly 20% of U.S. nuclear power plants will reach the end of their economic life span. Concurrently, the electric power industry will need to construct 75,000 MW of new generating capacity.

Success within the renewable energy sector will depend on the synergistic attitude of government, industry, and market forces. Some state public service commissions have approved incentive policies to promote the use of renewable sources, and many public service commissions have mandated that utilities study the inclusion of renewable sources in their existing generating capacity. Large utilities like Southern California Edison have spent over $100 million on solar development and are now

spending $150-$200 million annually to purchase solar power. Faced with an uncertain future of their electricity generation capacity, utilities may have no choice but to get energized on solar and wind power.

Similarly, DOE's R&D budget for renewables has increased steadily since 1990, when it was at its lowest point since the Carter years. R&D funding in FY95 has increased 17% over FY94, to $337.2 million.

Regulatory Impact. Three key pieces of legislation, PURPA, the CAAA90, and EPACT, have direct impact on renewable energy. The single most important event creating a market for renewable resources in electric power was passage of the PURPA. PURPA required electric utilities to purchase electricity offered by "qualifying" non-utility producers at their "avoided costs". Like NG, renewables are the benefactors of CAAA90 aimed at reducing sulfur emissions from fossil fuel energy sources.

Policy Issues. The costs of energy should be calculated to reflect environmental costs as well as any other benefits or disadvantages. Taxes are an effective means of accomplishing this task, though any new tax in the current political environment is unlikely. Tax policy may be used to encourage investment and development of renewable energy sources, as well as level the field by taxing environmentally unsound energy sources.

CONCLUSIONS

Over the last decade, there has been a significant shift in Government energy policies. In general, this shift is viewed as positive as government has taken a light-handed approach towards regulation, allowing market forces to operate in the energy industry. We saw this with the natural gas sector and we see it today with the restructuring in the electrical sector. This has led to a more competitive industry-more choice and lower prices for consumers.

Additionally, Government policies, particularly as enacted through the EPACT and continued by the Clinton Administration, have reinforced energy diversity, probably more to safeguard the environment than for energy security reasons. The winners are clearly the natural gas industry, renewables, and the clean coal technologies. The losers are the nuclear industry-which is not economically viable at this time given no substantial need for baseload and public opposition to nuclear-and to some extent, the U.S. oil industry, whose competitiveness is hampered by environmental regulation. As such, it is our recommendation that government take a balanced approach toward environmental regulation, based on risk consequences and performance standards. Additionally, greater Federal emphasis should be placed on policies that reduce oil vulnerability, including greater use of SPR to mitigate the consequences of petroleum shortages and tax policy as a means of promoting conservation, and funding R&D, and commercialization of alternative transportation technologies and fuels.

INDUSTRY STUDY

#10

ENVIRONMENT

TABLE OF CONTENTS

PARTICIPANTS

Students

BG Mohammed Abbadi, Jordanian Army

Mr. Michael P. Burke, OSD

LtCol Andrew E. Busch, USAF

LtCol Charles R. Davis, USAF

LtCol Robert J. Jarecke ANG

CDR Chris R. McKelvey, USN

LTC(P) Robert M. Reddick, USA

CAPT(Sel) Margaret R. Riley, USCG

LTC(P) Tommy H. Roberson, USA

Col Reese S. Shinkle, USAF

Mr. Bruce E. Thomas, Dept. of State

LTC(P) James E. Young

Faculty

Mr. James Caverly, Dept. of Energy

COL Thomas V. Mulrine, USA

Dr. Irene Kyriakopoulos

Col Joseph D. Rouge, USAF

PLACES VISITED

Domestic

Los Angles South Coast Air Quality Management District	Diamond Bar, CA
Atlantic Richfield Company Refinery	Carson, CA
Southern California Edison	Santa Anna, CA
Taylor-Dunn	Anaheim, CA
Fluor Daniels, Inc.	Irvine, CA
Louisiana-Pacific Pulp Mill	Samoa, CA
Bechtel	San Francisco, CA
California Environmental Business Cluster	San Jose, CA
Dupont Chemical	Wilmington, DE
Eastalco Aluminum Corporation	Frederick, MD
DoD Office of Environmental Security	Pentagon
DoE Morgantown Energy Technology Center	Morgantown, WV
CONSOL Coal	Blacksville, WV

International

OECD/IEA	Paris, FR
ELF Petrochem	Paris, FR
Ademe	Paris, FR
COGEMA	Le Hague, FR
Mercedes-Benz	Stuttgart, GE
IBM	Stuttgart, GE
ABAG	Stuttgart, GE
Research Institute Karlsruhe	Karlsruhe, GE
FRG Environment Agency	Berlin, GE
Auer	Berlin, GE

"The scientific and technological revolution has almost completely changed the physical realities of our relationship to the earth. With a dizzying array of new tools, technologies, and processes, we have extended our senses and magnified our ability to work our will on the world around us."

- Vice President Albert Gore, Jr.

INTRODUCTION

The preceding quotation from Vice President Al Gore was is from the National Science and Technology Council's (NSTC) publication entitled, Technology for a Sustainable Future - A Framework for Action. The NSTC is a cabinet level council chaired by the President;. Its charter is to coordinate science, space and technology policies throughout the federal government. An important objective of the NSTC is to establish clear national goals for federal science and technology investments.[1] Clearly, technology touches our lives in ways that only a few short years ago would have seemed unimaginable. Yet, technology is not without cost. One cost that has continually been highlighted since the first Earth Day celebration in 1970, is the effect of technology and economic growth on our environment.

The concern for the environment has spurred a whole new industry aimed at preserving and restoring our earth's delicate ecostructure. The environmental industry, if you will, has enjoyed significant growth in both the United States and abroad. Estimates of the U.S. market in 1990 ranged from $78 to $126 billion (B) (2.1% of Gross Domestic Product - GDP). Estimates for the year 2000 range from $113 to $213B (2.8% of GDP). Figures for the worldwide market of 1990 range from $200 to $295B expanding to between $295 and $426B in the year 2000. Over 30,000 firms provide goods and services in the United States with over 50,000 firms competing in the foreign market. Most firms in the environmental industry are small and are concentrated in the United States, Japan and Germany. Of the 80,000+ firms in the industry, fewer than 300 rate listings on the major stock market exchanges.

During the '93-'94 academic year, students in the Environmental Industry Study at the Industrial College of the Armed Forces conducted an in-depth study of the industry to include future potential, direction, and its effect on national security. The purpose of this year's effort is to build on the initial year's work from 1994 by expanding the scope of analysis and by providing each of next year's industrial studies (1996)a handbook or primer they can use in evaluating the

[1] Technology for a Sustainable Future - A Framework for Action. National Science and Technology Council, Washington D.C. 1994

effect that environmental issues have on their specific industry and on our economy at large.

Terms You Need to Know:

- Waste Stream: Waste produced as a result of a manufacturing process.
- End of Pipe Solutions: Application of technologies to the waste stream as it exits the manufacturing process.
- In Process Solutions: Application of technologies to eliminate, reduce or recycle waste inside a manufacturing process.
- Government Regulation: Policy and guidance, in the form of directives and enforcement that come from federal (e.g., EPA), state and local governments.

Why Industrial Ecology Matters:

As a student at the Industrial College of the Armed Forces we are swept up in the gaining momentum of the *Third Wave*, struggle to maintain our balance in the *Second Wave* and, are continually inundated with new and ever evolving paradigms. Unfortunately, another paradigm is looming on our horizon. This new and unavoidable paradigm bears the moniker of "*Industrial Ecology*."

Industrial ecology is the government/scientific label for the new wave in environmental thinking. Understanding industrial ecology is a necessary part of the industry study since "the fate of waste is a factor in assessing corporate competitiveness." ICAF industry study groups are interested in the current peacetime status of each industry including an evaluation of its operating efficiency and ability to remain viable economically, politically, and socially in the face of declining military budgets and increased international competition. Suggested questions to ask , during your year of sturdy, include:

- What long range policies is your industry implementing to remain competitive nationally?
- What factors influence the strength of this foreign competition?
- What is the impact of government regulation on your industry's competitiveness?"

The fate of waste is a factor in assessing an industry's competitiveness. A recent report by the World Resources Institute concluded that "cleanliness doesn't hurt competitiveness." The Economic Resources Group found "little

evidence to support the view that U.S. environmental regulations have had a large adverse effect on U.S. competitiveness." The private sector Competitiveness Council does not consider environmental regulation a major competitiveness issue but, oil industry executives cite environmental regulation as the reason for the lack of drilling and the construction of new refineries in the U.S.

Each industry, and company within an industry, will have a different perspective on the issue of waste and its cost. We need to understand an industry's position on this issue to be able to assess their actions and the actions they would like the government to take.

The Environmental Problem - The Old Paradigm

The U.S. has a history of environmental policy and legislation protecting its resources that stretches back to the beginning days of our nationhood. In the early 1800's, we had already passed legislation to protect our oak timber reserves from over harvesting and export. This was done to ensure that our shipbuilding industry had sufficient materials to build fast frigates that we needed for national security and for trade. While there were not a great number of environmental policies or laws in the early 1800's, activity did pick up in the latter part of the century partly due to our concern over over-exploitation of the resources of some industries, e.g., seals for skins for the fur coat market.

The pace of environmental policy and regulation continued to increase in the 1900's. By the time we were mid-way through the century, serious degradation of some aspects of our environment had become very apparent: waterways polluted; land contaminated; and air quality in cities poor. The 1970's standout as watershed years marked by the almost religious fervor with which we passed new environmental laws to halt the degradation--48 in just one decade. The pace quickened in the 1980's when we passed 80 new laws and continued in the early 1990's when in 1990 alone we passed 24 pieces of environmental legislation (including amendments).[2]

Today, there are 12 major environmental laws and volumes of regulations that our Environmental Protection Agency has primary responsibility for enforcing. There are also a myriad of other less monumental laws at the federal level, as well as, a plethora of state and local environmental laws. There are indeed layers upon layers of environmental regulations--enough to create confusion, contradiction, and frustration amongst the enforcers and those trying to run an industry. It is this layering and the concomitant impact on industry that has been the impetus for much of the current popular movement to curb passage of new environmental legislation.

---

[2] "Environmental Protection Laws and Treaties: Reference Guide". CRS Report for Congress, Congressional Research Service, 30 Jan 91, pp 1-11, 31.

Industry officials complain about the extent and quantity of environmental legislation, but more so about the inflexibility of the implementing regulations. They characterize the regulations as being very rigid and inflexible and indicate that because of the inflexibility, their initiative to try innovative prevention and remediation solutions has been stifled. In many cases, they believe the regulations are politically driven, rather than economically or rationally influenced.[3] Box 1 describes other characteristics of our current body of environmental regulations that industry officials have cited as having a negative impact on their firms.

Characteristics of Current Regulations

- Command and control based.
- Inflexible--all or--nothing regulatory approach.
- Reactive rather than proactive (with the notable exception of the Clean Air Act Amendments)--focus on end of pipe solutions rather than prevention.
- Based on performance standards rather than assimilation.
- Based on health/safety risks without regard to economic impact.[4]
- Create disincentives to apply/test new technology--disincentive in the form of fines and penalties.
- Address pollutants on an individual basis rather than on a holistic industry approach.
- Present barriers to expansion and new market entry within the U.S.--especially for smaller firms.
- Have become "drivers" for not only the environmental industry but the rest of industry as well.

Box 1

Today, however, just as industry is implementing some processes to deal with some of the most stringent amendments to the Clean Air Act are about to be implemented, there appears to be some regulatory relief in sight. Political forces, industry lobbies, and the general public are all mandating change--not change away from environmental protection, as some have charged, but rather away from the strict "health risk" basis for the regulations and away from regulatory inflexibility. Box 2 lists some of the current changes that could have significant impacts on the type, form, and style of our future regulatory environment.

---

[3] Non-attributional industry sources the IS visited.

[4] Technology for a Sustainable Future - A Framework for Action. National Science and Technology Council, Washington D.C. 1994, pp 15-24 and 66-79

THE WINDS OF CHANGE

- The Republican House "Contract With America" calls for regulatory relief.
- The Democratic Administration is also calling for regulatory reform and relief.
- EPA is implementing its "Common Sense Initiatives Program."
- EPA is implementing a risk sharing program for the development and testing of new technologies (CRADA).
- The Administration issued a comprehensive policy/strategy--outlining a balance between economic impacts and health based risks.
- Even at the state level, regulatory flexibility is appearing--e.g., Southern California's Air Quality Management District (SCAQMD) is working with local dry cleaners on a solvent emission problem rather than closing them down.

Box 2

The bottom line is that environmental regulation has had and will continue to have a significant impact on an industry's bottom line. While several major corporations have indicated that they are able to absorb the costs and have even profited from compliance with environmental regulations, there are many smaller companies which are struggling under the heavy regulatory burden. While no one we spoke with advocated abandoning the environmental legislation that we now have, there were those who indicated that government agency implementation of the intent of the laws needed revision. The good news is it appears from the people we spoke with that government at all levels is responding in a more positive, less adversarial manner than in the past. Government is attempting to "partner" with industry to solve problems and speed the development and marketing of new environmental technologies. In the meantime, industry's focus away from "end of pipe" solutions toward front end prevention measures such as hazardous material source reduction, process reengineering, and recycling will continue to be positive motivators for less regulation. The partnering efforts on the part of government and industry will ensure that economic impacts are considered as part of the legislative/regulatory process and help ensure that balance between economic goals and environmental goals do not sway in favor of one at the expense of the other.

A Symbiosis Between the Environment and the Economy

Despite assertions to the contrary, proponents of the environmental legislation of the 1970's, including that which created the Environmental Protection Agency (EPA) in 1970 itself, recognized the symbiotic relationship between the environment and our economic health. In its March 1985 report on Environmental Regulation and Economic Efficiency, the Congressional Budget Office (CBO) concluded that "(E)nvironmental regulation may improve productivity or increase economic output by incorporating pollution-related costs into economic decision making, thereby improving the economy's efficiency." According to the CBO, the fundamental issue is to ensure that the "external costs of pollution are correctly estimated and assigned to the production of the goods and services that lead to them, then the profitability guideline will lead decision makers in a 'competitive environment' to reduce the production of goods and services that generate pollution." Consequently, the societal costs of pollution will be reduced in terms of lives lost and damage to property that pollution causes.

Environmental Regulations aren't Economically Destructive

But is it true, as the would-be assassins of environmental regulations contend, that these rules constrain economic growth and contributes to inflation, unemployment and a host of other economic ills? This view is also held by Professor Paul R. Portney, who noted in his paper for Peskin/Portney/Kneese's volume on Environmental Regulation and the U.S. Economy, that the "...direct price, output, employment, and other macroeconomics effects of pollution control appear to be relatively small." Relying on several macroeconomic studies, but featuring those of Chase Econometrics Associates (CAE) and Data Resources Incorporated (DRI), Portney maintains that environmental regulations cannot be cited as either a "primary or significant" contributor to "... increased costs, inflation, reduced productivity, rising unemployment, the rate of economic growth, or lowered profitability." Based on his analyses, Portney concluded that there was at least an inference that the "social cost" (or opportunity cost) of environmental regulation is probably greater than "...actual direct expenditures for pollution control."

Some May Deliberately Inflate Environmental Costs

Nevertheless, as Portney observed, while "'all' costs" probably exceed direct expenditures, they fall considerably short of most estimates of (those) expenditures. He even suggests that some firms, especially those most affected by environmental regulations, "deliberately inflate" their expenditures to place the regulations they abhor in an unfavorable light. For Portney such shenanigans are counter productive not only to the individual firm's interests but also to the long-term interests of the economy. As he notes, "reliable information" is required in order to determine to the "nearest extent possible" how the costs of regulation may manifest themselves in the economy. Portney's prescription suggests that regulations can be tailored or, if need be, eliminated to minimize the impact on economic activity. He refers to this as "strategic environmental planning;" others have labeled it "sustainable development."

The Environmental Industry:

As previously indicated, the government's imposition of environmental regulation on industry gave birth to the environmental industry. There appears to be no true market force driving firms to be "green." The public's desire for "green products" remains limited in this country although a few U.S. firms have marketed products bearing a label declaring them environmentally friendly or made of recycled products. Indications are that these marketing approaches have been far more successful overseas in such nations as Germany and Japan then they have been here at home. Industrial firms involved in the new environmental paradigm have found themselves initially as unwilling participants, but have over time found it to be to their advantage.

The environmental industry that has arisen to meet the command and control nature of regulations is difficult to study using the traditional ICAF perspective. The standard industrial codes (SIC), do not help track the environmental industry. In fact, the 1994 environmental industry study team complained about the SIC situation and identified six different definitions of the environmental industry that are in use by different groups. The study team recommended a breakout of the industry by market (monitoring, pollution prevention, pollution control, and remediation and restoration); by media, i.e., what is being controlled (air, water, waste, and services); and products (ranges from analytic services to water utilities to waste management). In our overseas travel we have found that one source in Germany makes the distinction between industry sources of supply and demand: Suppliers being identified as product suppliers; demand coming from industrial firms needs.

We should not expect any action on the SIC or statistical front because neither industry nor government policy makers really seem to care about the overall number of firms in the environmental industry. Industry groups tend to keep track of their own. As a result environmental industry information can be found in trade publications. Of much greater interest to both groups is the global forecast for potentially increased environmental expenditures

Within this generally optimistic scenario, consolidation is the trend within many product areas. For example, the solid waste treatment sector is consolidating due to price competition and over capacity (800,000 tons of capacity vs. demand for 500, tons). Regardless of the consolidations, global demand is seen as an economic boon to the environmental industry and the American economy in general.

There is, however, a downside to this generally rosy picture. The estimates of future sales of both services and product are based to a large extent on the U.S. government's need to "clean up" federally owned sites. Given the operative set of environmental standards on the table today, the government's clean-up bill is staggering! At issue is whether the mandate to

clean up will actually result in funding. For without the requisite government funding, the forecast of large revenue fades. The second issue, and maybe the most significant for those in the environmental industry, is the changing focus of the manufacturing sector. Our discussion with industry leaders can best be summed In the following quote from a senior executive of a major chemical company, "Our goal is to improve our manufacturing processes to the point where we eliminate waste. In short we want to eliminate the need for an environmental industry. Hence, we have made a conscious decision not to enter the environmental industry for we feel in the long run its ability to be profitable is limited".

Three Views of the Environmental Industry:

Attempts to define the environmental industry inevitably focus on the technologies involved. While useful, this approach is limiting in many respects as it ignores both the regimes that the industry operates in and the roles that government and non-environmentally related industry play. To fully understand the environmental industry and the forces presently at work in our economy, a view encompassing all three definitions is required.

The "Technology" Approach: Environmental technology is a "technology that advances sustainable development by reducing risk, enhancing cost effectiveness, improving process efficiency, and creating products and processes that are environmentally beneficial or benign. The word "technology" to include hardware, software, systems, and services." Environmental technologies fall into four major categories:

- Avoidance activities involve technologies that avoid the production of environmentally hazardous substances or alter human activities in ways that minimize damage to the environment. Avoidance activities usually encompass product substitution or the redesign of an entire production process, rather than simply the use of new pieces of equipment.

- Monitoring and Assessment technologies to establish and monitor the condition of the environment.

- Control technologies render hazardous substances harmless before they enter the environment.

- Remediation technologies render hazardous substances harmless after they enter the environment and Restoration technologies embody methods designed to improve ecosystems that have declined.

The "Regime" Approach:

A second way in which to view the industry is through the frame of the regimes in which the environmental industry works. This approach focuses on the three major media where pollution is present and, by the way ,are the same three major areas in which government has imposed regulation. Specifically, these major groupings are:

Air *Water* *Solids*

The environmental industry has responded by the formation of firms providing services and products aimed at one or more of these regimes.

The "Player" Approach:

The third, and final, manner we use to describe the environmental industry defines it in terms of participants. While neither addressing technology nor regime, this approach provides a comprehensive view of all the sectors that guide and influence actions that impact on the environment.

Industrial "providers": The technologies used or the regime in which the technology is applied describe this sector. In either case, the "Provider" firms that have emerged are the typical ones associated with waste management and clean-up products and services. On the smaller scale, these are the companies that pick up your newspapers, plastics, used oil, etc., as well as those who further handle the waste and recycle it. Also, there are the larger concerns which deal in the business of providing industry the necessary products and services to deal with large, concentrated wastes. A good example of one of these entities is a provider of sulfur dioxide scrubbers for the smoke stacks found in the heavy manufacturing sector.

Industrial "users": The firms in this segment of the industry are in reality the manufacturing firms that are traditionally labeled as "polluters." This category is considerably larger and more diverse than the section of "providers." This manufacturing segment of our economy has slowly, often reluctantly, come to grips with the realities of being environmentally conscious. Initial remedial efforts focused on the waste stream, mirroring the focus of the regulators. Additionally, the manufacturing sector did not envision changing their production processes to reduce or eliminate waste. This created a considerable market for the "providers."

However, with the costs of handling and disposing of waste streams skyrocketing, the manufacturing industries started to approach the problem from another perspective; they began to look at the generators of the waste. As a result, these manufacturing firms have, in many cases, implemented techniques and technologies directly into their manufacturing processes that allow operation

within the standards set by the regulators with minimal or less reliance on the "providers" to deal with the end of the pipe waste stream.

A real plus for many of these manufacturing industries is that the "green approach" favorably impacts their bottom line . This is accomplished by eliminating end of pipe handling and disposal costs, fostering more efficient use of process materials, and, in certain cases, producing a marketable product which was previously considered and handled as a waste. What used to cost considerably to dispose of, now provides additional revenue or at least reduces production costs when the waste product is reintroduced into the production process. A notable example occurs within the chemical industry where by changing the production process, at least one company has increased production efficiency by reducing the input stream, found a market for the two major by-products of the process, and closed a landfill where the waste was being stored. The result has been not only a more robust bottom line, but a significant reduction in landfill maintenance costs and potential long term liability.

Government: Our study of the environmental industry has clearly indicated to us that to exclude government from any description of the industry is to perhaps ignore the most important force at work within the environment today. Without a doubt, the many successes that we as a nation have enjoyed in safeguarding and protecting the environment were launched by direct government intervention via regulation. Left to their own devices, the manufacturing segments were content with the "business as usual approach." That being the case, the providers of environmental services and products would have had no impetus to step forth. If ever an industry was fostered and nurtured by direct government involvement, the providers of environmental goods and services were and continue to be.

As one studies the effects of environmental concerns on a particular industry, it is important to continue to bear in mind the three ways described above to view the environmental industry, for each provides a useful framework. However, the third framework, that folds government into the recipe is perhaps the most useful for the role that government has played and is likely to play, even in the light of a Congress bent on regulation reduction, will no doubt remain significant. In all fairness to the manufacturing sector, it should be said, that there are firms that take great pride in being "green" and would do so without prompting. However, we observed this to be the exception to the rule in domestic industry while in Europe it appeared to be part of the "corporate culture." What is generally the case is that government forces manufacturers to comply with a set of standards and have overtime found that not only can they comply, but they can be more efficient and thus more profitable.

The Future of the Environmental Industry:

Expenditures on environmental technologies will change as we move into the future. The best way to explore these changes is by taking an imaginary trip to the year 2040. During the early part of the new century, investments in remediation will have cleaned up a large proportion of existing hazardous waste sites. Intensified expenditures in technologies to avoid environmental harm will have paid off significantly. Manufacturing processes will be more efficient in the use of resources, consumer products will embody environmental design, and the infrastructures that supply energy, transportation services, water, and food will be more resource efficient and environmentally benign. By 2040, most industries will be approaching a zero-discharge goal requiring few control technologies to deal with residual discharges into the environment. Investments in large macro scale monitoring systems and new macro sensors will permit continual assessment of the state of the environment at multiple scales. At some future date, we will have moved from an environmental paradigm based on cleanup and control to one based on anticipation, avoidance, and assessment.

David Foreman and Saddam Hussein: Ecoterrorists

The world knows Saddam Hussein and the effects of his deliberate ecological terrorism unleashed upon Kuwait: Millions of barrels of oil spilled in the Persian Gulf; over five hundred oil wells set ablaze by retreating Iraqi soldiers. Remarked EPA Administrator W.K. Reilly after visiting the area in May of 1991, "If Hell had a national park, it would be those burning oil fires." Truly, Saddam can be labeled a 'world-class' ecoterrorist.

But who's Dave Foreman, and why does he carry the same moniker? In early 1980 he founded Earth First!, an environmental activist group loosely fashioned on the exploits of a band of renegade environmentalists as they plot to destroy the Glen Canyon Dam in Edward Abbey's 1975 novel, The Monkey Wrench Gang. Using the monkey wrench as their symbol, Earth First! quickly became known for their own brand of 'monkey-wrenching' -- vandalizing construction equipment and logging operations, and street-theater-type protests.

Foreman and four local Arizona activists were arrested in a DEA-type raid in 1991 when an FBI sting operation revealed a conspiracy to sabotage two nuclear power plants in Arizona and California, and a nuclear-weapons facility in Colorado. Although Foreman was not accused of participating in the conspiracy (in fact he had stepped back from some Earth First! activities because of their increasing militancy), he was accused of helping to finance the operations.

The resulting trial ground to a halt after four months with plea bargains, mostly due to the unraveling of the Federal case. It was revealed that the actions of an infiltrator into the group, an FBI plant, had goaded the militant activity and became the driving force behind the planned sabotage activity.

As an ecoterrorist, Foreman's message was one of "monkey-wrenching" to make people aware of the environmental destruction being levied upon the planet. Saddam, on the other hand, was an ecoterrorist who had no message other than reeking the worst possible environmental havoc upon the land to deny its use by others.

Industrial Ecology - The New "Green" Paradigm

While the corporate officers of every industry we visited or talked to are mindful of their responsibility to their stockholders, all professed to be concerned about the deterioration of the environment and what kind of world their grandchildren would inherit. They seek to find the balance between being environmentally responsible and making a profit--i.e., they strive to achieve sustainable development.

Sustainable Development

A 1987 report, Our Common Future, by the World Commission on Environment and Development, introduced the concept of sustainable development as a form of development or progress that "meets the needs of the present without compromising the ability of future generations to meet their own needs."[5] There is some disagreement as to the precise meaning, but most interpretations refer to the viability of natural resources and ecosystems over time, and the maintenance of human living standards and economic growth--they meld the dual objectives of environmental protection and economic growth. Thus, inter-generational equity--assuring that business decisions made by the present generation take into account impacts on future generations--is central to the concept of sustainable development.

Consequently, a new paradigm is emerging. Enlightened, progressive, forward thinking companies have discovered environmental-friendly processes and consumer goods are "good business." The company that can change its inputs and processes, increase efficiency, and avoid or eliminate wastes, or turn wastes into commercial by-products, has the competitive advantage. The company that clings to the old processes must comply with increasingly stricter environmental regulations--it pays dearly for less efficient operations, "pollution credits," output control (scrubbers, filters, etc), waste disposal, and remediation, all of which only detract from the bottom-line. Therefore, not only is it good for public relations to be environmentally sound, investment in industrial ecology is both profitable and an investment in the future--a future we must all invest in, and help re-engineer.

---

[5] Schmidheiny, Stephen, Changing Course, The MIT Press, Cambridge, MA, 1992, pp. 5-6.

Industrial Ecology

A systems approach to the ecosystem/environment is the key to sustainable development. Systems expert Donella Meadows defines a system as any set of inter-connected elements.[6] In his book Lean and Clean Management, Joseph Romm says: "Inter-connections are the essence of the ecosystem." and suggests we learn from nature. "One creature's waste is another's food. Nature squeezes every last bit out of its resources."[7] Two researchers at the GM Research Laboratory in Warren, Michigan put it this way:

> The traditional model of industrial activity--in which individual manufacturing processes take in raw materials and generate products to be sold plus waste to be disposed of--should be transformed into a more integrated model: an industrial ecosystem. In such a system the consumption of energy and materials is optimized, waste generation is minimized and the effluents of one process--whether they are spent catalysts from petroleum refining, fly and bottom ash from electric-power generation or discarded plastic containers from consumer products--serve as raw material for another process.[8]

Romm offers the town of Kalundborg, Norway as an example of industrial ecology. A dozen diverse enterprises, including an electric power plant, an oil refinery, district heating, a biotechnology production plant, a plasterboard factory, a sulfuric acid producer, cement producers, and local agriculture and horticulture operations cooperate and are commercially interconnected. There are also examples here in the U.S.; one company we visited found it was economically advantageous to sell a by-product at a loss rather than to pay to dispose of it as a waste. This trend will grow as industry places more focus on applying environmental technologies to front-end processes in order to avoid and eliminate wastes.

Environmental technologies explained and technology development scenarios

Environmental technologies advance sustainable development by reducing risk, enhancing cost effectiveness, improving process efficiency, and

---

[6] Meadows, Donella H., "Whole Earth Models and Systems," Coevolution Quarterly, Summer 1982, pp. 98-108.
[7] Romm, Joseph J., Lean and Clean Management, How to Boost Profits and Productivity by Reducing Pollution, Kodansha America, Inc., NY, 1994, pp. 33-34
[8] Frosch, Robert A. and Nicholas E. Gallopoulos, "Strategies for Manufacturing," Scientific American, Sept 1989, pp 144-152

creating processes that are environmentally beneficial or benign.[9] Although there is no clearly identifiable industry driving the market for environmental technologies, there is general agreement that these technologies focus on four major areas.[10]

Monitoring and Assessment - Increasingly rigorous standards and the regulation of a growing list of substances drives market growth in this segment.

Pollution Prevention - Unlike the other areas, pollution prevention offers the potential to improve operating efficiencies and contribute to growing profits. The necessary self-examination of routine and accepted work habits moves industrial operations to reconsider the use of hazardous materials, selection of recycling alternatives, or the use of less hazardous solutions.

Pollution Control - Commonly referred to as "end-of-pipe" solutions, these technologies strive to control the toxicity of waste streams through a separate processing to remove hazardous materials.

Remediation and Restoration - One of the unwanted remnants of our earlier industrial operations is the need to correct the mistakes left by others. The need for sophisticated technologies to lower recovery costs and provide greater restoration efficiencies is creating significant opportunities.

Two major trends are emerging in the area of environmental technologies. First, the technological focus is shifting away from pollution control measures to a more enlightened approach using pollution prevention and avoidance to meet increasingly rigorous standards. Second, despite a robust domestic demand, growing markets for environmental technologies are emerging overseas. The U.S. is a strong market force but isn't the dominant force in providing these services.[11]

During our California trip, we visited the Environmental Business Cluster (EBC) and observed an eclectic gathering of start-up firms that had little in common other than their focus on providing a service that qualified in one of the four areas of environmental technology. The EBC personified these two trends in their activities. Entrepreneurs were developing technologies contributing to pollution prevention such as alternatives to incineration and economically

---

[9] Technology for a Sustainable Future - A Framework for Action. National Science and Technology Council. Washington D.C. Page 9

[10] Environmental Technologies Exports: Strategic Framework for U.S. Leadership. Interagency Environmental Technologies Working Group. Department of Commerce, Washington, D.C. November 1993, pp 8-9

[11] Environmental Technologies Exports: Strategic Framework for U.S. Leadership. Interagency Environmental Technologies Working Group. Department of Commerce, Washington, D.C. November 1993, pp 9

feasible fuel cells to replace fossil fuel burning power generation. Furthermore, several of these entrepreneurs reported that their "out-of-the-box" solutions were receiving greater acceptance in foreign markets and openly speculated that the technological edge may migrate away from the U.S..

Government

Regulation - Long gone are the days when the environment was a free good in the manufacturing process. The air is no longer an inexhaustible heat sink and water can't process endless quantities of pollutants. General public outrage and concern over the past 40 years has forced Congress to act on this matter of national interest. Initially, we gathered all the "low-hanging fruit" in our attempts to control pollution. The method of choice for early regulation was the "end of pipe" solution dictated by a strict command and control methodology.

In fact, the Congress' continued willingness to involve itself in the issue may be developing as part of the problem. Our old regulatory focus is starting to generate process inefficiencies that inhibit continued improvements in environmental technologies. The "Valley of Death" phenomenon provides a graphic representation of the issue. The command and control methodology provides a minimum standard for which there is no economic incentive to try to improve.

Incentives - One of our corporate hosts provided the best illustration of the current inefficiencies with our command and control methodology. Our speaker pointed out that his company received hefty fines for isolated and non-recurring failures to meet standards. Conversely, his company was recognized for their long-term and sustained improvements in environmental compliance with an insignificant ceremony. The bottom line: provide real incentives to sustain improvements in the environmental quality.

Partnering - The EBC provides appropriate seed examples of the partnering needed to sustain the growth of environmental technologies. The entire EBC structure is supported by venture capital and focuses on bringing technologically promising innovations into a network of mutual support. Perhaps most important, the EBC assists members in developing the business skills and strategy that many of the technologically gifted individuals need.

"A paradigm shift is emerging among those who pollute and generate waste - a shift from controlling and cleaning up pollution to preventing pollution and minimizing waste."

Grant Ferrier, President
Environmental Business International

Why should they be "Green"?

In a capitalist economy, profit is the great motivator. Industry and business will become "green" if they see that being "green" provides a competitive, profitable advantage over the competition. Profitability accrues to companies or industries which produce products more efficiently than competitors, produce better products, and which more adeptly market their products. Going "green" can provide positive contributions in these areas. While not all inclusive, some of these attributes are identified next.

- Using "green" technology can contribute to a more efficient production process. The capturing of traditional waste material and byproducts and turning them into energy sources can reduce energy costs. This also can eliminate costs associated with waste disposal. Application of efficient, pollution prevention hardware may require less energy thus again reducing costs.

- Innovation, driven by the requirement/desire/need to become "green" may allow for the development and adaptation of new products -- being the first and only firm in a market usually means profit.

- Implementation of continuous process improvement may provide cost advantages -- usually does.

- On the marketing side, the selling of "green" products and industries using "green" processes to the public is not difficult if these products are competitive in price. In fact, given a competitive price, individuals will normally buy the more environmentally sound product. This is an educational and marketing task.

How do American firms begin using technology, innovation, improvement, and marketing to increase profits by becoming "green"? The answer is to develop a level playing field first in the U.S. and then globally. This begins with domestic policy and regulations. The following outlines three ways in which regulation can help provide a competitive advantage.

a. Regulation. Pollution prevention regulations may increase competitiveness if it results in firms paying closer attention to continuous process improvement. Regulation could also drive modernization if it led industry to upgrade production facilities or to invest in new, more productive facilities.

b. Innovation. When properly structured, regulation stimulates innovation in the environmental control industry. Regulations may create pressures on firms to develop new products, thus adding to the dynamism of the economy.

For example, regulation is credited with encouraging a number of new automobile technologies. In some cases, over-coming problems related to regulation may have enhanced firms' problem-solving capacities and contributed to commercial innovation.

c. Improved Environment. This is the least effective of the three ways regulation may help competitiveness. If environmental regulations create benefits in excess of costs, then economic well being is the result. Lower levels of pollution may lead to lower health care costs, increased agriculture and labor productivity, and lower costs in other parts of the economy. These benefits may accrue to firms both directly and indirectly through cheaper supplies and inputs. Unfortunately, expenditures occur in the present and benefits occur in the future.[12]

These regulatory changes are very close to the hypothesis Michael Porter presented in his book The Competitive Advantage of Nations. Porter argues that while environmental regulations impose costs and other constraints on industry, they may also stimulate innovations and/or efficiency gains which offset costs. He outlines four ways innovation can help offset the negative impact of compliance costs. These are:

- Countries with strict regulations are likely to develop firms providing environmental goods and services. Their products are required by industry to meet regulatory requirements. A competitive advantage may be obtained by producers by having this "captive" market.

- Regulations stimulate the development of innovative or higher quality products.

- Properly constructed process standards can encourage companies to re-engineer technology to reduce not only pollution, but also costs as production processes become more efficient.

- Regulations can lead to competitive advantages only if they are performance-based standards as opposed to prescribing particular technologies.[13]

The driving force to any change in either policy or regulations must begin with the government (this, of course, does not preclude industry or individuals from suggesting or proposing changes either directly, through groups, or via the legislature). The most significant change the government could make in order to foster competitiveness of U.S. firms in a global market is a revision of attitudes

---

[12] U.S. Congress, Office of Technology Assessment. Industry, Technology, and the Environment, U.S. Government Printing Office, Washington, D.C., 1994, Page 83-85

[13] Porter, Michael E. The Competitive Advantage of Nations. The Free Press, New York, New York, 1990, Pages 647-649

and thinking. Instead of contributing to an adversarial climate, the government must become a partner with industry. In this light, government could help all industry through such ventures as cooperative research and development, assisting in establishing industry consortia, or creating a method of publicizing and sharing technology and innovations. In the regulatory field, government needs to move from a prescriptive format to performance-based regulations. Additionally, in both the policy and regulatory fields, the government must move toward prevention and away from control and remediation. On a broader level, examination of incentives for prevention, innovation, clean-up, etc. should be examined. These could be tax incentives, patent enhancement, creation of public awareness, etc. Still other measures might be import/export controls for environmentally sound producers.

Any and all of these measures would require a serious change to current thinking. In many cases, it would require significant political will. While U.S. firms complain about government interference, history shows industry is often reluctant to change -- any change.

On the world scene, the government can help develop and create a more level playing field through the use of alliances, treaties, agreements, trade/manufacturing associations, and the use of import-export restrictions or incentives.

The U.S. continues to have some of the world's strictest environmental standards. Many people argue for a relaxation of these standards in order to enhance U.S. competitiveness. With an ever increasing debt, trade deficit, and balance of payments, there is much sentiment for this viewpoint. However, there are many European countries as well as Japan which compete globally while adhering to strict domestic environmental standards. In order to compete and provide a vibrant, capitalistic economy in the future, both government and industry are at a critical juncture in history. How government and industry now respond will effect the U.S. economic position well into the 21st century.

If being "green" is both good and profitable, why isn't American industry moving faster in this direction? The answer appears to lie in our culture. A culture which has fostered inefficient and restrictive government policy and regulation, a culture which allows special interests of a few to override common good, and a culture which causes business and industry to focus on the short-term instead of the long term. A brief look at each of these factors follows.

Prior to 1970, states and localities dominated environmental control requirements. A major concern was businesses relocating from areas with strong pollution control standards to areas with lax standards thereby penalizing jurisdictions endeavoring to protect their public health and environmental quality. As a result of this concern, legislators adopted baseline environmental standards

which would be nationally uniform (states can typically impose standards more strict than Federal standards, but not less so).

In the late 1960s and throughout the 1970s as concern for the environment grew, so did government regulation at the national level. There are two views on what these regulations have done. One is that implementation has been costly to business and a waste of public funds to operate agencies in overseeing implementation. The bottom line of this view is that regulation costs businesses billions of dollars, businesses are over-regulated in general, and regulations have contributed to difficulties for the U.S. to compete internationally.[14]

The second view is that environmental regulations are not a major determinant to industrial competitiveness. Factors such as competent management, capital cost and availability, work force skills, and market access play more significant roles than environmental regulations.[15]

Regardless of which view one accepts, regulation does impose some cost on doing business and in a competitive global environment any cost is important. While costs are important, the majority of complaints from industry focus not on the direct costs of control, monitoring, and the like, but rather on the less easily measured costs associated with what are perceived to be inefficient regulatory processes. A common complaint is that American firms are burdened by overlapping regulatory jurisdictions, complex and lengthy procedural requirements, and excessively detailed, prescriptive regulations promulgated by inflexible regulatory institutions. It is also asserted that uncertainty about the future course of regulation has inhibited technological innovation and investment in research and development.[16]

Regardless of whether government policy and regulations are a significant factor in competitiveness or only play a minor role and whether they are efficient or inefficient, one thing is certain, the majority of regulations are of the "command and control" type. This system has led to a highly adversarial climate between industry and government. This system provides little incentive for technological development or innovation.[17]

Another cultural factor inhibiting American industry from aggressively adapting "green" processes, procedures, and technologies is the influence of

---

[14] Losman, Donald L. and Liang, Shu-Jan. The Promise of American Industry, Quorum Books, New York, New York, 1990, pp. 84-85

[15] U.S. Congress, Office of Technology Assessment. Industry, Technology, and the Environment. U.S. Government Printing Office, Washington D.C., 1994, p. 18

[16] Dertouzos, Michael L.; Lester, Richard K.; and Solow, Robert M. Made In America, Harper Prennial, Massachusetts Institute of Technology Press, Cambridge, Massachusetts, 1989, p. 111

[17] U.S. Congress, Office of Technology Assessment. Industry, Technology, and the Environment, U.S. Government Printing Office, Washington, D.C., 1994, p. 23

special interest groups on government policy. For example, the oil industry has historically opposed (with success) enactment of environmental laws and regulations. In 1986 twelve of the fifty largest U.S. companies were oil companies and when ranked by sales, nine of the largest twenty-five were oil companies. This concentration of wealth buys political influence at all levels of government. Being large and profitable, coupled with a short-term outlook, promotes little incentive for change."[18]

Corporations must answer to their stockholders and stockholders are interested in profit. U.S. corporations operate on a quarterly balance sheet. Long range planning is frequently less than five years and quite often in the one to three year range. This is one reason businesses have frequently viewed introduction of environmental controls as a cost -- the investment cannot be recouped by the next quarter.

Conclusion:

As you pursue the study of your chosen industry, it is important that you have an appreciation for the effect that environmental considerations have on the decision and investment cycles of the firms that you will study and visit. During our study of the environmental industry, we unearthed several key points that we believe will be of benefit to you.

Industry is Environmentally Aware. Without a doubt American industry is cognizant of the environment and the relationship that exists between those firms that provide environmentally related goods and services and government. It can be argued how this awareness came to be, but the fact that it exists is undeniable. Expenditures on capital equipment, positioning of new production facilities, new product designs, modifications to manufacturing processes, expansion to new markets and marketing techniques are all being impacted upon by environmental issues.

Industry is also aware that the cost of being environmentally conscious is not a show stopper, does not drive firms out of markets nor does it cause companies to fold. While all of these effects were voiced by industry in the early stages of environmental awareness, the message being voiced today is that environmental costs are simply a cost associated with doing business. These costs are now viewed in the same light as costs associated with complying with OSHA requirements, medical insurance or the cost of capital once were. The phenomena being played out in the market place has generally manifested itself in the realization that being green is profitable and manufacturing processes that reduce or eliminate the waste stream increase efficiency and the corporate bottom line.

---

[18] Moore, Curtis and Miller, Alan. Green Gold, Beacon Press, Boston Massachusetts, 1994, p. 184

Increasing Emphasis on "Process Engineering". The initial industry response to the imposition of regulatory requirements on production processes was to treat the waste stream at the end of the pipe. Solutions varied but, in general waste was: detoxified to an governmentally established standard; a penalty was paid for non-compliance; the waste was captured, contained and stored away to be dealt with at a later date; or, some combination of all three. These solutions are all expensive, inefficient, and create the potential for long term liability to the creator.

Industry has now taken a more enlightened approach, by opting to amend processes to reduce or eliminate the waste stream. Dependent on the nature of the manufacturing process and subsequent waste stream, your industry may have elected to change the nature and composition of the input stream by using non-toxic materials, installed pieces of environmental technology that clean or scrub the waste stream, found a market for the by products of the production process or continued with end of pipe solutions. All the evidence indicates that the key to environmental compliance, production efficiency, and profit lie in the modification of the production process.

Industry Doing Environmental Engineering "In house". Firms have generally three choices in how they deal with the waste stream. They can turn to the traditional suppliers of environmental goods and services - the traditional environmental industry. They can seek third party engineering and design firms to develop clean production processes or they can develop solutions in-house.

Our investigation indicates that the most successful firms have adopted the latter course. By developing solutions to their production process in-house, they reduce the costs associated with out sourcing, benefit from the knowledge gained in the pursuit of the solution, and, lastly and most importantly, they maintain proprietary rights that result in a *competitive advantage.* Firms that have developed process solutions are unwilling to license or market their technology and thus forego potentially lucrative income flows to retain the edge on their competitors.

Long Term - Future May Be Limited to Clean-up Efforts. Because industry has already embraced or is developing environmentally sound production processes, the future of the traditional environmental industry is in doubt. As was stated earlier, there is a massive clean-up effort, both in our country and abroad, waiting to be funded. The rate at which funding is provided will to a large measure determine the size and composition of the environmental industry.

Regardless of the clean -up rate, the face of environmental industry is changing:

a. Focus will move away from clean-up and toward the development of techniques and systems to monitor waste and to determine what really constitutes a hazard to the ecosphere.

b. Reorganization, downsizing, consolidation and abandonment will occur within the environmental industry as manufacturing process solutions eliminate waste.

c. Firms associated with recycling will grow as a result of the tightening of land fill use and the increasing ability of the manufacturing sector to reuse materials.

The Role of Government Will Evolve. Undeniably government got the environmental awareness ball rolling, but the corporate bottom line combined with public pressure will keep it in motion.. As was discussed earlier the traditional government approach to the environment has been to establish standards and impose technology. The future will see the continuance of an emerging trend that features a partnering of industry and government to establish standards and then government stepping back to allow industry to find the best solution.

INDUSTRY STUDY

#11

FINANCIAL SERVICES

TABLE OF CONTENTS

PARTICIPANTS

Students

David Bentley

James Buchanan

Luis Camacho

Gary Carter

David Clifton

William Cook

Joseph Dodd

Chester Huber

John Johnson

Stephen Kee

Marty Martin

Stephen Peters

Al Runnels

Tim Savage

Tom Sechler

Dick Stevens

Faculty

George Fidas

Capt T.J. Anderson, USN

PLACES VISITED

Domestic

Securities and Exchange Commission
Office of the United States Trade Representative
Board of Governors, Federal Reserve
National Association of Securities Dealers
World Bank
Federal Reserve Bank of Richmond
T. Row Price Mutual Funds
International Monetary Fund
U.S. Secret Service
Chicago Mercantile Exchange
Chicago Board of Trade
Chicago Options Exchange
New York Stock Exchange
Goldman Sachs, New York
Wall Street Journal, New York
Federal Reserve Bank of New York
Prudential Securities of New York
New York Mercantile Exchange
New York Clearing House of International Payments
Morgan Stanley, New York
Paine Webber, New York
Chemical Bank, New York
Bankers Trust, New York

International Travel

London International Futures Exchange
Financial Times of London
Bankers Trust of London
European Bank for Reconstruction and Development, London, UK
Merrill Lynch Europe, Ltd., London, UK
Bank of England, London, UK
Frankfurt Borse, Frankfurt, Germany
Deutsche Bank, Frankfurt, Germany
Deutsch Bundesbank, Frankfurt, Germany
Commission of the European Union, Brussels, Belgium
U.S. Mission to European Union, Brussels, Belgium
Bank of France, Paris, France
Organization for Economic Cooperation and Development, Paris, France
U. S. Embassy Paris - Financial Attache

INTRODUCTION

Finance is predominantly psychology--greed and fear--and a lot of detail.
-Managing Director, major NYC investment bank to ICAF Seminar, 4/5/95

It is, of course, the details that set the world of finance apart for most laymen. Incredible sums transmitted in electronic bursts effect daily economic transactions through processes that strike the uninitiated as little short of alchemy.

Americans must develop a more sophisticated grasp of the financial services industry both domestically and internationally. In personal terms, it is a matter of personal advantage, learning how to protect hard-earned assets by investing them wisely. On a larger scale, the health of our financial services industry is central to U.S. national security. The capacity of the industry to allocate capital effectively and efficiently is critical to maintaining the strong industrial base that undergirds U.S. defense capabilities.

Michael Porter outlined the importance of financial services from a national security perspective in his book, Competitive Advantage of Nations:

> The upgrading of an economy requires that ample capital is available at low real cost and is allocated efficiently through the banking system and other capital markets to investments with the highest productivity. A low cost of capital not only encourages the high levels of investment necessary to improve productivity, but also supports sustained investments by lowering the time discount rate . . . Government has a role in affecting both the supply and cost of capital as well as the markets through which it is allocated....A nation's supply of capital is most influenced by the personal savings rate, the size of the government surpluses or deficits, and the foreign capital flows . . . Government policy can affect all three. . . .Controlling government deficits that are not being used to finance productivity-enhancing investments in the economy is perhaps the most direct way in which government can influence the pool of investable capital. . . . Efficient mechanisms for allocating capital are as important to economic upgrading in many ways as the availability of capital. Successful emerging companies must have open and fair access to a nation's pool of capital in order to fund growth and the pursuit of higher-order competitive advantages.[1]

This paper analyzes key elements of the U.S. financial services industry, highlighting important trends and issues. Three primary themes that have particular national security implications for the United States are:

o The U.S. Federal Budget deficit, national debt, and low savings rates (poor financial discipline).

o The increasingly interlinked global financial markets and the dramatic affect of technology on them.

o The degree to which the American form of corporate governance allows U.S. firms to compete globally.

DOMESTIC STRUCTURE

Introduction

U.S. financial services have been shaped recently by forces outlined above. Among the most noteworthy results is a tendency toward diversification of services by financial institutions. Historically, institutions operated within a narrow band of services:

o **Commercial banks** controlled the payments system, clearing checks and drafts; today, money is transferred electronically among any number of financial firms in volumes that could never be efficiently handled in physical form.

o **Savings and loan associations** were the primary source of residential mortgage financing, with the S&Ls holding the loans to maturity; today, mortgage finance is available from an array of sources and mortgage loans are traded as securities.

o **Securities firms** concentrated on corporate and government securities as investments; today, these firms offer close substitutes for bank deposits and help industrial firms bypass the commercial banking system as they pursue short-term financing.

o **Insurance companies** relied heavily on whole life policies; today, insurance companies offer products that compete with investments sold by securities firms.

The following segments detail some of these changes, looking at commercial banks in the depository sector, investment banks, insurance companies, and mutual and pension funds in the non-depository sector, and the Federal Reserve System and the Securities and Exchange Commission in the regulatory sector.

Commercial Banking

Commercial banks, once the staid Main Street symbols of American finance, have been among the most dynamic and innovative segments of the financial services industry during the last decade and more. Forced to diversify to meet competition from other financial institutions and propelled by technological advances, commercial banks have moved away from their traditional role as depository institutions- deposits in and loans out - -toward providing one-stop shopping for financial services.

Shaping forces. Change is taking place amidst pressures and debates that have characterized the U.S. commercial banking sector since its origins. Tensions, some creative and some not, have resulted from commercial banks' efforts to satisfy often competing national goals and agendas.

o Liberal lending is demanded but with soundness.

o Responsiveness to local needs is desired, but so is the strength of a regional or national base.

o Diversified services are preferred, but without public liability (e.g. FDIC) for the associated expansion of risk.

Regulatory Impulse. Another formative tension has pitted the economy's need for expanding, responsive depository institutions against the need to protect the depositing public. Since the mid-19th century, the Federal Government has acted to maintain confidence in the banking system and protect citizens from the consequences of banking failures. Banking legislation is replete with evidence of this regulatory impulse, dating from the National Banking Act of 1864 which established a national banking system, to the Banking Act of 1933 which established the Federal Deposit Insurance Corporation (FDIC), to the Riegle-Neal Banking Act of 1994 which opened the way for increased interstate banking. Interested parties argue for more or less regulation, with bankers protesting suffocation, and others counselling caution. The public's interest lies, as usual, in the government striking the proper balance between the competing needs for economic freedom and public welfare.

Diversification. Commercial bank profits were threatened in the early 1980s as other depository institutions (savings banks, mutual banks, credit unions) outbid them for deposits, and their traditional commercial loan customers were lured away by commercial paper and the availability of funding from pension and mutual funds. Commercial banks survived, and then prospered, by developing cost efficiencies, emphasizing fee-generated services, and persuading regulators to allow activities in such areas as real estate, securities, and insurance. If the current campaign to remove the Glass-Steagall prohibitions against mixing commercial and investment banking succeeds, diversification will probably gain new momentum.

Technology Push. Like the rest of the financial services industry, commercial banking has been profoundly altered by related revolutions in computer technology and telecommunications. As money has been transformed into electronic impulses, speed and cost efficiencies have multiplied, and nationwide banking in now feasible. Regulators are challenged to keep pace with new products and services. Internationally, the U.S. comparative advantage in the banking sector derives from its being the most innovative and technologically advanced.

Investment Banking

With investment banking, your assets walk out the door at 5 PM every day.
-Managing Director, major investment bank to ICAF Seminar, 4/6/95

Investment banking encompasses the world of securities firms known as "Wall Street." Activities common to investment banks include:

o **Securities underwriting** which involves raising capital through the creation and sale of new securities, both equity (stock) and debt (bond). If the sale represents the original issue of equity in a previously privately held company, it is called an Initial Public Offering or IPO. Securities underwriting is the making of a primary market.

o **Secondary market activities** include executing securities transactions for retail and institutional clients, usually through one of the many exchanges.

o **Proprietary trading**, i.e., trading securities for profit in the firm's own account and using its own risk capital, has become a key profit source for most investment banks.

o **Mergers and acquisitions** are handled by a separate department that provides business and financial analysis and advice. A subset of this business, pursued by both major investment banks and specialty firms, is providing advice and financing for **leveraged buyouts** (LBOs), in which publicly owned firms issue new debt in order to buy back their outstanding equity and become privately held. This practice was carried to controversial extremes in the 1980s.

o **Asset management** for wealthy clients.

o **Analytical services** are supplied by a department that studies industries, usually by segment, to support the profit centers of the firm.

This array of activities and services is typical of a large, full-service investment bank. Some firms target specific activities, providing, for instance, retail security brokerage, or offering a full-range of services but only on a regional basis.

The possible repeal of Glass-Steagall barriers to mixing commercial and investment banking would restructure the industry, perhaps radically. The existing relaxation of commercial bank underwriting of debt securities has allowed J.P. Morgan, a commercial bank, to capture a significant share of the market, bidding down fees and profitability in the process. A full repeal of Glass-Steagall could trigger an acquisition binge, with commercial banks seeking second-and third-tier investment banks. Commercial bank success in investment banking, with its complex, fast-paced, unique culture, is uncertain. Looking to the future, the concept and practice of risk management for proprietary trading portfolios has become a critical challenge, given the extreme leverage and volatility of positions in complex derivatives.

Mutual and Pension Funds

Ten years ago, if you thought investing in Mexico was a good idea, you'd have had no idea how to go about doing it. Now, it's as easy as dialing 1-800-mutual fund.

-Economist, Major securities firm

Mutual funds have been around since the 1920s, but they became the vehicle of choice of millions of American individual and institutional investors in the 1980s and 1990s. Participation of individual investors emerged with aging "baby boomers" concerned about retirement and possessing the education discretionary funds and education to make investment decisions. On an institutional level, expansion arose from various sources, but the shift to defined-contribution retirement plans provided a particularly lucrative pot for mutual funds. At the close of 1992, mutuals held about a quarter of the $400 billion 401 (k) plan assets.

Explosive Growth. A glance at the numbers reveals the dramatic emergence of mutuals as a source of investment funds in the 1980s. From their origins in 1924 until 1940, only 68 funds were created, with assets under $500 million. From 1973 to 1992

mutual fund assets increased from $46.5 billion to $1.595 trillion. Today there are roughly 4,500 funds with $2.1 trillion in assets. By 1992, 27% of Americans owned mutuals, as opposed to 6% in 1980. Mutuals and the pension funds that help nourish them are expected by some analysts to each exceed $8 trillion in assets by 2003.

Money Market Funds (MMFs) paved the way in the 1980s for the mutuals' explosion. They provided small investors an opportunity to invest in high-grade, highly liquid, short-term assets (U.S. Treasury bills, large CDs, commercial paper) that had previously been available only to those able to post large minimums (often $100,000). By 1983, MMFs accounted for 75% of net assets of all mutual funds. As Americans grew familiar with mutuals, a rising stock market and falling interest rates led to a rapid increase in holdings of long-term bond, equity, and income funds.

Convenience Pays. The easy availability of mutuals and the varieties in which they come help account for their popularity. Brokers sell them, as do banks and insurance agents, and they can be purchased through home computer, and--in another tribute to the impact of technology--through ATM machines owned by the Wells Fargo bank in California. There are types of funds for every interest and tolerance for risk. Among the most notable are those that provide both small, unsophisticated investors and huge institutional investors the chance to invest in emerging markets. Mutual funds invested in Mexico and their rapid withdrawal at the first sign of trouble played no small part in that country's 1995 financial woes.

Insurance

Like other segments of the financial services industry, insurance is no longer a case of agents plying an assortment of whole life, term, and health policies, occupying a neat, well-defined niche quite isolated from other aspects of the customer's financial life. A generation ago, customers forced a sea change on the life insurance industry by "unbundling" coverage in whole life policies. They covered pure insurance needs with cheap term policies, and moved the investment portion of their premiums into instruments with higher yields than whole life insurance e.g., money market certificates, mutual funds, etc.). Insurers responded with new products like universal life that coupled insurance coverage with investment products offering performance-based yields. Until the early 1990s, annuities also provided a lucrative alternative, but insurance companies have encountered stiff competition from banks. The investment portion of annuities and life insurance products could both lose their preferential tax status in a deficit-conscious era.

Banking with Insurance? As "Baby Boomers" move toward retirement shrinking the base for selling traditional insurance products, insurance companies are considering broader services to meet their financial needs. The possible repeal of Glass-Steagall would create opportunities, among them amalgamation of insurance and banking interests. Insurance agents blanche at the thought of competition from banks, but insurance companies see an efficient alternative to the costly agent distribution system, and one with

a huge consumer market for insurance, annuities, mutual funds, etc.

Property-Casualty Insurance. More frequent natural disasters since the 1960s have severely taxed the industry, raising average annual costs from $1 billion in 1960 to $12 billion in 1993. Problems continued into 1994 with the Northridge, California quake ($6.9 billion loss) coinciding with plunging bond markets that slashed the insurance companies' capital and surplus, and made offsetting underwriting losses with investment profits difficult. Risk exposure has also been increased in recent years by:

o More people buying catastrophe insurance in exposed areas, especially after Hurricane Andrew and the Northridge quake;
o Terrorism (World Trade Centers bombing cost insurers $500 million); and
o Increased business risks resulting from such developments as concentrating operations in fewer, high-tech facilities.

Catastrophic coverage has shrunk dramatically in California and Florida (less so in other areas), in part because of tax provisions related to reserves to cover losses and the political difficulty elected insurance regulators have approving premium increases. And in the relatively new area of environmental insurance, the enormous liabilities created for insurance companies under "Superfund" (Comprehensive Environmental Response, Compensation and Liability Act, 1980) have led many insurers to claim the risks are uninsurable precisely at a time when demand for environmental coverage is increasing.

More Government Risk. Many argue that the answer is for the Federal Government to assume more risk, following the precedent of a 1968 federal flood insurance program ($270 billion) initiated when private insurers concluded flood damage was uninsurable. Proponents argue such programs are cheaper than disaster relief. The insurance industry is currently backing a bill that would provide guaranteed federal catastrophe reinsurance to companies that comply with certain provisions. Detractors argue that such a program would aggravate moral hazard (i.e., the tendency of policyholders to act imprudently knowing someone else will pay the bill) and reduce the pressure on underwriters to diversify risks. Inherent is added financial risk for a government pressed to demonstrate financial responsibility and respectability.

Promise of Derivatives. Insurers are beginning to use derivatives--usually futures and options--to hedge risk. These products offers a new source of capital and the prospect of insurers expanding coverage of currently uninsurable risks.

Federal Reserve

At times in 1994, Federal Reserve head Alan Greenspan dominated evening broadcasts, crowding out the President, Congress, and other newsmakers. The Chairman's high profile helped surface issues about the Fed's accountability, Greenspan's own power, and, as the dollar's plunge began in 1995, about the Fed's continuing ability to

affect the flow of international currency markets.

Origins and Structure. The Federal Reserve System--the nation's central bank and in many ways the foundation of the U.S. financial services industry--was created in 1913 to restore public confidence in a panic-ridden banking industry by lending it a measure of stability and credible supervision. The system today consists of 12 regional Federal Reserve Banks operating under the guidance of the Board of Governors, a 7-member, federal government agency headquartered in Washington D.C. The banks are non-profit entities that last year turned back to the U.S. Treasury $16 billion earned above operating costs.

Functions. The Federal Reserve Board and the Fed banks have a multifaceted mandate, including regulatory and supervisory duties over part of the banking system, customer protection, and the provision of payments services. The Board's most important duties, however, involve the making of U.S. fiscal and monetary policy. On fiscal policy, the Fed is under the control of the U.S. Government and acts essentially as the U.S. Government's bank, handling the accounts of the U.S. Treasury. The Fed also acts as a government agent in carrying out its roles in consumer protection (credit and other financial transactions) and bank supervisor and regulator. This latter field is the growth industry for the Fed as Congress keeps adding duties. The Fed shares bank regulatory responsibilities with the Office of the Comptroller and the Federal Deposit Insurance Corporation. The roughly 1000 state banks that are members of the Federal Reserve System and all bank holding companies fall under the Fed's purview, along with foreign activities of member banks and U.S. activities of foreign banks.

National Security Concern. When the Treasury Department decides to intervene in currency markets to influence the dollar's exchange rate, the Fed acts as Treasury's agent. The early 1995 plunge of the dollar against the yen and the deutsch mark has surfaced deep concern not only over whether the U.S. should intervene, but also over whether the Fed--and, therefore, the U.S--has the clout in international currency markets to get the job done. Has the sovereign ability of countries, any country, to defend its currency been overwhelmed by the sheer volume of daily currency trading, and, if the answer is positive, has a national security vulnerability been created? Daily transfers through New York's Clearing House of International Payments (CHIPS) average about $1.2-1.4 trillion. Fed spokesmen claim that a $1-2 billion intervention can still be influential if it is strategically timed, but their argument sounds more hopeful than compelling.

On monetary policy, the Fed is an independent actor, empowered by its 1913 charter legislation to develop and implement monetary policy so as "to promote effectively the goals of maximum employment, stable prices and moderate long-term interest rates." The Fed uses three basic policy tools to implement its monetary policy decisions:

o Altering reserve requirements for member banks, thereby constricting or expanding their loanable assets;

o Altering the rate at which banks borrow from the Federal Reserve Banks, the so-called discount rate; and

o Entering into open market operations by buying or selling securities.

Changes in the discount rate are more closely reported in the media, but open market operations are the Fed's most powerful, flexible, and precise tool of monetary policy because the securities' transactions result in a dollar-for-dollar change in the reserves of the depository system. Decisions on these operations are made by the Federal Open Market Committee (FOMC) which meets 8 times a year and consists of the Board of Governors, the President of the New York Fed and 4 of the other 11 Reserve Bank presidents sitting on a rotating basis.

Too Much Power? Does this non-elected entity exercise too much power over monetary policy? Economists and politicians alike tend to agree that independence in monetary policy lies at the heart of the Fed's role as a central bank. Undermining that independence would be at the expense of the domestic and international credibility of the U.S. financial system.

Securities and Exchange Commission

We ensure the glass doesn't get too foggy to see through.
-SEC official to ICAF Seminar, 2/3/95

The Federal Reserve's regulatory counterpart for securities markets is the five-member (Senate-approved) Securities and Exchange Commission (SEC). Created in 1934 as part of the New Deal adjustment to the 1929 market crash, the SEC is charged with administering the laws that seek to protect investors. Independent, nonpartisan, and quasi-judicial, it ensures that publicly held entities, broker-dealers in securities, investment companies and advisers, and other participants in securities markets comply with federal securities laws.

U.S. laws are based on the assumption that the public and the markets must have sufficient information to make informed investment analyses and decisions. U.S. regulations, therefore, require far greater disclosure by companies and broker-dealers than in Germany or Japan. A senior research specialist in a prominent U.S. banking firm maintains that the disclosure requirements are insufficient. He insists that the "great secret of the U.S. financial system" is the fact that the five years of data companies are required to file are not sufficient to draw trend lines and reveal volatility that would disclose risk. He terms this a "major flaw" in the U.S. regulatory system.

INTERNATIONAL STRUCTURE

Introduction

Global economic and financial recovery and stability were, in large measure, dropped in the lap of two institutions by the Bretton Woods Conference in 1944--the International Monetary Fund and the International Bank for Reconstruction and Development or World Bank. Both remain critical cogs in the international financial system, although both are being forced to adjust to changing roles.

In the private sector, U.S. financial services firms have long held a comparative advantage in terms of technological innovation and product creativity. The segments below on the European Union's financial services, comparative capital markets and corporate governance, and the Export-Import Bank all deal with various aspects of U.S. international competitiveness in financial services, as well as in the broader industrial context.

International Monetary Fund

The IMF's move away from its traditional role of providing balance of payments support is too bad because a series of such problems is coming and the IMF is without the capital to handle the problem.

-Editor, international financial newspaper to ICAF Seminar, 5/5/95

With Mexico facing financial chaos and Russia struggling through a difficult conversion to a market system, the world community has turned to the International Monetary Fund (IMF) for help, as it has for 50 years. Its role has evolved with the times, but a strong, capable IMF remains a central premise of the international financial system.

Origins. The IMF emerged from the 1944 Bretton Woods conference, paired with the World Bank as the institutions to guide post-WW II economic and financial recovery. As conceived, the IMF's job was to stabilize international currency values in order to promote international trade, this within the context of the fixed exchange rate system established at Bretton Woods. The IMF is structured more as a credit union than a commercial bank. Countries subscribe by paying a quota which, in turn, establishes the level of the country's "drawing rights," or access to currency to solve short term monetary problems.

Course Corrections. Since opening its doors in 1946, the IMF has significantly altered its mission on two occasions, innovating and adjusting to changes in the international financial system.

o In 1971, the Nixon Administration bowed to the pressure exerted on the dollar by the fixed exchange rate system and suspended the conversion of the dollar to gold, unilaterally creating a floating exchange rate system. With the need to

stabilize the Bretton Woods system gone, the IMF focused on providing members "stand-by" credits to alleviate balance of payments problems, and created extended repayment products, stretching the repayment period from 2-3 to 5-10 years. Essentially the Fund became the lender of last resort for financially troubled nations through the 1970s and early 1980s.

o In August 1982 Mexico announced it could not pay its creditors, thereby unleashing what would be a decade-long international debt crisis, with the IMF playing a crucial role as honest broker between debtor nations and their commercial creditors. Early in the crisis, the IMF worked with debt-ridden governments to implement and monitor economic restructuring programs which the banks used to justify additional lending. By the end of the decade, this strategy had done little but increase indebtedness, intensify inequities in the distribution of wealth, and open the IMF to criticism as the bagman for the commercial banks. In 1989 the IMF threw its support behind a debt reduction strategy that would become known as the "Brady Plan" after U.S. Treasury Secretary Nicholas Brady. Again the IMF changed gears, moving from its function as monitoring authority and collection agent to that of a development banker focused primarily on economic growth and prepared to offer debtor countries an array of technical assistance programs linked to financial development.

Russian Challenge. Given its unique financial tools and experience, and its political neutrality, the West entrusted the IMF with managing over $24 billion in aid to Russia from various sources. The problems are staggering, and at this early juncture, the IMF's technical assistance resources are as important as its money. Russia provides the best example of how valuable the IMF can be as an adjunct to U.S. policy in politically sensitive areas of great strategic importance.

Hot Money Chase. Mexico's most recent financial crisis has again drawn in the IMF, this time as a participant in a rescue package spearheaded by U.S. aid. More relevant for the IMF's future, however, are ideas that have been prompted by the "Hot Money" odyssey that undermined the Mexican peso. Some propose a more aggressive and anticipatory surveillance role for the IMF, allowing it to identify problems earlier and alert debtors and lenders to emerging problems. Others are toying with the seemingly less feasible notion of setting up a world bankruptcy court in the IMF to permit an orderly resolution of matters when debtors cannot pay.

World Bank

After 50 years in the business of promoting development among the world's poor nations, the International Bank for Reconstruction and Development (IBRD) or World Bank is at the center of a debate over its lending record and future directions.

Structure. The Bank is composed of four institutions with separate mandates:

o The IBRD, the single largest provider of development loans to middle-income developing countries; it makes loans at roughly market rates with the general objective of reducing poverty and financing investments that contribute to growth (roads, schools, irrigation projects, dams, etc.).

o The International Development Association (IDA; 1960), the Bank's "soft loan" window which provides subsidized loans to the poorest countries.

o The International Finance Corporation (IFC; 1956) enables the Bank to make private sector loans not permitted by the Bank's original charter.

o The Multilateral Investment Guarantee Agency (MIGA; 1988) encourages private sector investment in developing economies by guaranteeing them against non-commercial risks such as war and nationalization.

Operations. The Bank uses contributions from members as collateral to raise capital on private markets. All 177 members are represented on the Board of Governors by cabinet-level officials, but the Bank's daily business is carried out by the Board of Executive Governors on which the 5 largest contributors have individual seats and the remaining nations are represented by 1 of the 17 other Executive Governors. Voting is weighted according to contribution, with the U. S. controlling a 16% share. Voting on Bank loans is supposed to be based solely on economic criteria, but political considerations frequently intrude. U.S. representatives, for example, are directed by law to vote against loans to some countries on human rights grounds. The U.S. has the power to veto loans from the IDA's "soft window" because it contributes a greater share of the IDA's capital.

Record. Since 1944, the Bank has loaned over $300 billion to fund over 6,000 projects in about 140 countries. Despite ad hoc evidence of successes around the world and a general sense that it has contributed significantly to global economic and social progress, the Bank's impact is difficult to measure, and its failures are all too easy to isolate and highlight.

Bank Pressured. Critics have attacked the Bank from two general angles:

o Liberal economic ideologues argue that by lending to the public sector in developing countries, the Bank has nourished statist, interventionist policies that inhibit development.

o Others criticize the negative impact of Bank loans in specific areas, alleging, e.g., that they have triggered deforestation, displaced native peoples, or sparked rural violence. Most notable here is a global coalition of over 200 religious, environmental, labor, student, and human rights groups which has organized a campaign entitled "50 Years Is Enough."

Road Ahead. While there may be merit in a review of the Bank's policies and directions, its position as the major source multilateral developmental assistance is probably not in danger. Its agenda now includes not only the continuing needs of the

world's poorest, but also new challenges arising from developments in Central and Eastern Europe, Russia and the Commonwealth of Independent States, and the West Bank and Gaza. From the U.S. viewpoint, the Bank improves regional and global stability, and provides a vehicle for exerting political influence by voting for or against loans, and extending assistance to areas where unilateral U.S. assistance might be unacceptable for various reasons.

Capital Markets and Corporate Governance

Why Corporate Governance? The conventional wisdom is that our primary economic competitors, Japan and Germany, have superior systems of corporate governance. *Keiretsu* and main banks in Japan and cross-shareholding and *hausbanken* in Germany, it is argued, encourage a longer view by management which allows strategic investments to capture market share and develop new technologies, as well as stability and consideration for key non-owner stakeholders such as employees, suppliers, and customers. The rise of Japanese and German economic might since World War II supports the perception of superior corporate governance.

Anglo-American corporate governance, on the other hand, is allegedly short-sighted. Uninvolved investors demand share price maximization at any cost. This objective is pursued through Wall Street's focus on quarterly earnings momentum. Corporate raiders and hostile takeovers enforce market choices on management groups that do not heed the message. This conventional wisdom provides a useful backdrop for analyzing strengths and weaknesses and offering recommendations for the U.S. system.

The American, Japanese, and German systems of corporate governance reflect not only cultural differences, but also differences in the development and regulation of their capital markets. Each system has strengths and weaknesses. The American system is based on equity finance and widely dispersed ownership of shares traded in highly liquid markets. Banks are not large shareholders in any one company. The Glass-Steagall Act (1933) separates commercial and investment or merchant banking, and the Bank Holding Company Act (1956) restricts banks from holding more than 5% of the stock or otherwise controlling an industrial firm.

Under U.S. law, banks (or any lenders) that exert effective control over a firm are subject to "equitable subordination" of their debt if a bankruptcy arises, so banks seldom exert such control. Pension funds own almost two-thirds of institutionally-owned stock, but are restricted in voting power and have virtually no representation on corporate boards. Similarly, a welter of regulations inhibit mutual funds and insurance companies from establishing large holdings in single companies.

Corporate boards of directors, created to oversee management in the interest

of owners, contain both inside and outside directors. Inside directors are executives of the firm. Outside directors specifically represent the interests of shareholders, but rarely are they direct representatives. They are usually third-party senior executives (often retired CEOs), business school academics, attorneys, or respected retired public officials.

Wall Street analysts monitor virtually every publicly-traded firm's performance. Their opinions drive investors' decisions, as shares are heavily traded and rapidly repriced in liquid and efficient equity markets. Small variances in quarterly earnings from analysts' projections can result in substantial share price pressure, up or down, as supply and demand clear in the market.

Investors demand prevailing returns adjusted for perceived risk. Firms that consistently under-perform the market or fail to achieve an acceptable return on otherwise marketable assets, are put "in play" by takeover specialists who attempt to replace the company's management to achieve appropriate returns. Shareholders also have recourse to litigation against directors, auditors, and other parties who fail to represent their interests.

<u>Japanese Governance.</u> The roots of Japanese corporate governance lie in *zaibatsu*, family-owned conglomerates that evolved under military rule in the 1930s and 1940s. After World War II, the *zaibatsu* were broken up and financial regulations similar to those in the United States were instituted. In the 1950s, however, former *zaibatsu* members created *keiretsu*, a system of cross-shareholding, and main banks became primary shareholders.

In a *keiretsu*, cross-shareholding will control from 30% to 90% of each firm's equity. A president's council, composed of the leaders of member firms, meets monthly. The main bank will have extensive lending as well as equity holdings in its associated firms. For example, Honda's main shareholders are The Mitsubishi Bank and The Mitsubishi Trust and Banking Corporation.

Japan's system of main banks and *keiretsu* has produced "Japan, Inc.", the closed, interwoven business and financial powerhouse that has captured enormous worldwide market share. The system has allowed a long-term perspective on investment as well as a willingness to subordinate investor demands for high returns. It has allowed the undertaking of strategic conquests which yield returns below even Japan's excellent cost of capital.

<u>German Governance.</u> Germany's financial and corporate governance system is, in many respects, similar to Japan's. Banks dominate the ownership and control of publicly-held industrial firms. There is no American-style regulatory separation of commercial and investment banking. The only restriction on bank share ownership is that no single issue may exceed 15% of a bank's capital. Beyond owning significant

stock, German banks serve as depositories for private investors' shares. Under this depository concept, *Depotstimmrecht* and *Vollmachtstimmrecht,* German banks virtually control the proxy of each deposited share. As a result, they control approximately 50% of all German corporate shares.

German corporations have two-level boards of directors. The *Aufsichtsrat* is a supervisory board similar to American outside directors. By law, half of the members are elected by the work force. The other half, including the chairman, are elected by shareholders. These directors are heavily drawn from *Hausbanken* or cross-shareholding firms' executives. An executive board of managers constitutes the lower tier of German boards.

The German system of corporate governance, with its rule of the *Hausbanken,* provides stability for long-term investment. Worker representation on the *Aufsichtsrat* ensures extraordinary labor power and compensation by American standards. Cross-shareholding interlocks industrial groups similar to *a keiretsu.* Bankruptcy is rare. Restructuring and dispute resolution is conducted by the banks. As in Japan, this system contributed to German industrial success in the post-WW II period.

German and Japanese firms have prospered from the stability of their financial and governance systems. As described above, they have made strategic investments with long payback periods in product and manufacturing technology, the training and stability of their work force, and in longstanding relationships with customers and suppliers up and down the value chain. The interlocking of financial and industrial firms, especially in the *keiretsu,* has served as a de facto industrial policy that defends against imports and direct foreign investment while allocating resources to targeted industries. But signs of trouble with the system are emerging as the post-war economies of Germany and Japan mature.

Stability has become stagnation. Governance by main banks or *Hausbanks* has been unable to lead the restructuring of firms in mature industries with excessive costs. Volkswagen is struggling to reduce excess employment. Japanese firms suffer from vast over investment in fixed capacity. Ryuji Yasuda of the consulting firm McKinsey estimates that Japanese firms employ one million excess workers. Japanese corporations are under pressure to raise return on investment to enable them to issue new equity. The Japanese Government is pressuring firms to maintain excess capacity to preserve employment. The systems lack the ability to enact creative destruction.

The American financial and corporate governance system, on the other hand, excels at creative destruction. Capital and labor are rapidly reallocated in efficient markets. Firms fail or are restructured. New firms constantly emerge, often in whole new industries--biotechnology, computer networking, etc. Opportunistic takeover artists and dispassionate financial markets prevent stagnation. This messy system

forces management to be accountable to owners, and forces capital and labor to seek their most productive returns. The American corporate governance system offers a sustainable national competitive advantage to the United States.

Improving the U.S. System. The challenge is to encourage strategic management without harming the dynamic nature of American markets. Two measures have appeal:

o Amend Glass-Steagall (1933) to encourage the evolution of commercial banks towards merchant banking.

o Redefine the legal concept of "equitable subordination" to allow bank governance to play a more productive role during debt work outs.

These moves would allow American banks to bring a long-term view on investment to their involvement with industrial firms. Similar reforms could allow limited management participation by mutual funds and insurance companies.

The Bottom Line. The conventional wisdom is incorrect. The American system of corporate governance is successfully competing in the world economy. The industry must study the structure, conduct, strengths and weaknesses of our competitors, and develop unique practices that will overlay their strengths on the American system. But in doing so, they must avoid the temptation to mimic aging systems whose rigidity is becoming detrimental to the vibrancy of their economies.

European Union Financial Services

The European Union (EU), America's chief competition in financial services along with Japan, is following the 1980's financial revolution in the U.S. and Japan by liberalizing financial services as part of its efforts to establish a unified, integrated capital market.

Slow Start. The goal of European integration was established by the 1957 Treaty of Rome which established the EU, but concerted attention to economic integration lagged until the 1980s. Not until 1986 did the EU adopt the Single European Act with its legislative and procedural framework for accomplishing a unified and integrated market by 1992, including a financial common market. By 1993, the EU had removed all restriction on capital flows. Members states are now obliged to:

o Ensure their residents access to financial systems in all EU countries.

o Remove all restrictions and discriminatory barriers on capital transfers.

The system operates on the "single passport" concept which holds that financial institutions are ultimately supervised by their country of license, and host-

country control is limited to the right to protect the "public good" and the "public interest" in such matters as monetary policy.

Benefits and Leverage. Analysts believe that the EU will achieve greater efficiencies in allocating savings and investments because the single financial market will provide a higher return to savers, a lower spread between lending and borrowing interest rates, a lower cost of capital, and better hedging and diversification techniques. EU leaders clearly anticipate tapping the financial services' yet unrealized potential, and redirecting its benefits to EU firms and citizens. The design is to break down the compartmentalization of EU financial markets, enhance the attractiveness of Europe as a location for financial business, and help channel a greater portion of existing savings into European businesses and investment projects. Ultimately, creation of the EU single market is expected to facilitate creation of a common EU currency and central bank.

Implications for the U.S. EU complaints about barriers to the operation of its financial firms in the United States are not likely to be translated into sanctions. Although reciprocal treatment could become a serious issue with Japan and its structural barriers to entry. The strength of a unified EU sector might speed entry into the Japanese market, a goal shared by the United States. In the near term, the single EU financial market will have little impact on the strategic plans and operations of U.S. financial firms, although there may be opportunities in specific market sectors:

o **Banking:** U.S. banks will have opportunities in a European wholesale banking market that has been largely deregulated for some time. U.S. companies with merger and acquisition experience can expect opportunities from cross-border merger activity in the EU.

o **Securities:** U.S. firms should benefit from their vast experience in marketing and packaging the kinds of new investment vehicles--including derivatives--that should be in greater demand in the EU single market.

o **Insurance:** Considerable opportunities are expected in markets for both liability/casualty insurance for large risk customers and life insurance, because liberalization is well along in both areas.

The major impact of the EU market structure on the United States may lie in the support it will provide those who would rescind the Glass-Steagall and McFadden restrictions on U.S. industry. U.S. firms operating in the EU under its new unified structure will want similar conditions in the U.S.

Long-Term Threat? If the EU financial structure works as planned, it will shift the terms of trade in, and the economic benefits of, EU financial services toward EU members and citizens. The redirection of capital to European markets could complicate the debtor stance of the U.S., and more robust financial services could stimulate the growth of the D-Mark and/or ECU as reserve currencies.

Export-Import Bank

Established in 1934 to facilitate trade with Russia and China, the Export-Import Bank (EXIM) is now charged with promoting the export of U.S. products and services throughout the world. Since 1934, it has helped finance the sale of over $300 billion in U.S. goods and services, with record sales of $17 billion in each of the last two years.

EXIM operates on yearly appropriation from Congress. It is authorized to make direct loans, issue loan guarantees, and provide export insurance up to a total outstanding balance limit of $75 billion. EXIM does not compete with commercial providers of trade financing and tends to work with smaller companies that have difficulty acquiring commercial financing for one reason or another. The result is a higher risk profile than most commercial banks, although by law EXIM engages only in transactions that offer a reasonable assurance of repayment.

The composition of EXIM-financed deals is critical with respect to both customers (countries) and products. Its focus is not only on facilitating trade with major developing countries, but also on promoting the export of high technology, high value-added capital assets with both infrastructure and national security implications.

In this period of Government downsizing, EXIM's annual $1 billion appropriation might be a tempting congressional target based on market logic, i.e., if a U.S. firm can not compete in the international marketplace without government help, maybe it should not make the sale. Counter arguments come from two sources. Some observers accept market logic only so long as American firms enjoy a level playing field in international competition. The lack of that condition, they argue, justifies aggressive EXIM support for U.S. exporters. Others defend EXIM's activities under the rubric of strategic trade management, i.e., seizing the current unprecedented opportunity to foster long-term relationships between strategically important U.S. industries and emerging countries is in the national interest. Establishing a ground floor position, proponents insist, creates jobs in the United States and advances our agenda with emerging new players.

TRENDS

Foreign Currency and Transnational Capital Markets

...a country which is responsible for the key currency of the world has the responsibility of maintaining reasonable stability
-Michel Camdessus, International Monetary Fund Director

A major financial issue over the past year has been the crash of the U.S. dollar against foreign currencies, particularly the Yen and the deutsch mark. Many factors have affected this dramatic fall, some of which can be controlled by Americans, some of which cannot. Some are tangible, some are not. This section summarizes the situation, its

causes, and national security implications.

Since 1990, the dollar has lost 42% against the Yen. From January to April 1995, the dollar lost nearly 20% of its value against the Yen and more than 10% against the deutsch mark. Although a rebound is occurring in May 1995, some reputable experts predict the dollar will fall to 70 Yen and 1.2 deutschmarks over the next 5 years (down from 103 and 1.7 respectively in April 1994).

Why a falling dollar? The principal causes are psychological as well as fiscal:

- o Strong confidence in the German central bank;
- o Depressed Japanese economy and closed markets;
- o Weak confidence in the U.S. economy due to poor fiscal discipline;
- o Chronic U.S. trade imbalances;
- o Previously overvalued dollar;
- o Comparatively poor savings rates in the U.S.; and,
- o A Mexican bailout which imposes more economic problems on the U.S..

Consequently, holders of U.S. currency have gone from eager holders, to anxious holders, to (some) enthusiastic sellers.

Why worry about the dollar's demise? Apart from loss of national prestige and global leadership credibility, there are several reasons. First, a falling dollar means that Americans are poorer. Second, since the United States must borrow much of its budget deficit from foreign sources, the reduced value of the dollar makes it more difficult to borrow at steady, low rates. Third, a devalued dollar can put inflationary pressure on the domestic economy if imports are consumed at an undiminished rate. Fourth, it has a depressing impact on the export-led economies of Japan and Germany.[2] Fifth, there is increasing potential that international traders in global financial markets will impose market discipline on the U.S. Finally, there is concern about the general impact of turbulent currency markets on the global economy. High volatility of cross-currency values makes trade less efficient by increasing risks and transaction costs.

Has the dollar become undervalued? Probably. Debt and trade deficits aside, the U.S. economy is not doing badly. GDP growth is high. The value of equities (i.e., stocks) is up, inflation is steady and low by U.S. standards, interest rates are up but still moderate, investment is up, unemployment is low, production and leading indices are on a steady upslope, and business failures are down. Even the debt situation is showing signs of improvement as the current account deficit shrinks as a share of GDP. If Congress and the President do not backtrack on fiscal deficit reduction rhetoric, even better trends can be expected in the future. Some argue that U.S. budget deficits diminish in significance when measured as a percentage of GDP, i.e., the U.S. debt is 1.8% compared to Japan's 1.8% of GDP, Germany's 2.4% and France's 5%. Likewise, net public debt (all levels of government) is projected to be 40% of U.S. GDP in 1995 compared to 47% in Germany

and 43% among other large industrial nations.[3]

What can be done? Two traditional actions can be taken to offset currency fluctuation according to traditional theory:

- **Intervene in the market.** Central banks buy dollars, making them more scarce, therefore more valuable.
- **Raise interest rates.** Higher rates make dollar-denominated, fixed-income assets more attractive, raising demand for dollars.

Many doubt that market intervention by central bankers remains an effective tool to control currency volatility and protect currency value. Nearly $1.5 trillion flows across national borders each day in transnational currency markets that lack institutions and laws. This amount totally overwhelms the combined reserves of the central banks of all major developed countries ($384 billion)--even in the unlikely event they could agree on unified action. Central bankers in the U.S. and UK optimistically continue to ascribe psychological value to the "signal" sent by market interventions. Traders worldwide scoff at the futility of such gestures, often viewing them as acts of desperation. Raising interest rates may prop up an ailing currency in the short run, but usually is accompanied by economic contraction.

Market volatility.

The transnational economy is shaped mainly by money flows rather than by trade in goods and services. These money flows have their own dynamics. The monetary and fiscal policies of sovereign national governments increasingly react to events in the transnational money and capital markets rather than actively shaping them.

- Peter Drucker[4]

Ten minutes is an eternity in international currency terms.

- Foreign Exchange Director of major securities firm

Market turbulence has been aided and abetted by technological advances, including the telecommunications revolution. In a process often compared to casino gambling, huge, fast-moving markets can now instantly react to anticipated or perceived events and trends on the global stage. The results can reinforce minor trends (positive or negative) nearly instantaneously, 24 hours a day, potentially escalating minor market disruptions into national or global crises. *Washington Post* reporter John Berry, speculated about a worst case scenario in which greatly accelerating, uncontrollable, negative shifts in currency could effectively shut down the system for handling financial currency, right down to the cashing of a check at the local supermarket. Importantly, the ability of sovereign governments to control or check turbulence is increasingly in doubt.

Financial institutions invest hundreds of millions of dollars in computer technology each year and hire theoretical mathematicians, physicists, and chemists to create and

manipulate esoteric models to manage currency trading. These same technological leaps have called into question the notion of sovereign control over currencies and the effectiveness of national regulatory regimes.. Ideally, technology can be used to monitor as well as play the markets, however the regulators are behind. While some vulnerabilities are guarded against (e.g., natural disaster, criminal intent, electronic failure), regulatory and jurisdictional issues are concerns. Few effective buffers exist to prevent shifting tides of money from swiftly deepening and spreading any new political or currency market crisis. The Open Market Committee of the New York Federal Reserve, for example, still tracks currency quotes using a blackboard and chalk..

One way the the Fed might keep up with the rapidly changing financial and foreign exchange situation is to station officers overseas in the capitals of our major trading partners such as Japan, Germany, Mexico, Canada, Belgium, and the European Community in Brussels. Virtually all of our trading partners have central bank representatives living either in New York or Washington to monitor the Fed and engage in regular dialogue with Fed managers. Incredibly, the Fed currently has none.[5]

Other circuit breakers to dampen volatility of currency exchange might include:[6]

o Increasing financial transparency by requiring governments and central banks to make prompt, full disclosure of information about their economies so as to help prevent nasty surprises that could cause investors to pull out their money abruptly.

o Improving surveillance by beefing up the IMF's capability to know what is happening in markets and blow the whistle publicly when financial problems emerge.

o Establishing international default procedures by setting up a world bankruptcy court within the IMF to allow orderly resolution when a nation can not pay debts on time.

o Creating a bailout fund to provide credit to a government whose default might threaten the financial system.

o Instituting additional capital controls.[7] For developing countries, limit short-term foreign borrowing or investment; for industrial nations, institute controls similar to those used in the 1950s and 1960s to limit capital outflow.[8]

o Reexamining the floating dollar. It is absurd for a global economy to depend on currencies that change value to the degree recently experienced.

o Establishing a goal and methodology to stabilize interest rates.

o Taxing currency transactions. If markets can't be slowed, skim something off which might be used for international development or assistance.

o Establishing international market regulations. [9]

<u>Summary</u>. Whether the U.S. dollar remains the world's reserve currency depends to a considerable extent on the attitudes and decisions of others. However, the factors affecting these attitudes are within our leaders' ability to control or influence, and they have crucial national security importance. In the near term, a devalued dollar probably hurts others more than the U.S. But, as long as root causes such as deficit spending and low savings rates go unchecked, the long run economic implications for our posterity are

disquieting to say the least.

Derivatives

A derivative is not just a product. It is a solution to a problem. Derivatives get blamed for losses when the human piece is really at fault.

-Derivatives specialist, Foreign branch of U.S. bank to ICAF Seminar, 5/3/95

People are reaching out for returns that amount to a gold ring. They don't know what they are doing.

-Executive, Major U.S. commercial bank to ICAF Seminar, 4/6/95

Introduction. On February 27, 1995, newspapers throughout the world heralded the bankruptcy of England's venerable financial stalwart, Barings PLC. The reason was the abuse of derivatives, the archetypical financial product of our technological age. Since that debacle and a similar one in Orange County, California, the financial and popular press has debated the merits of derivatives, with experts lining up on both sides, while more "victims" have reported serious market losses.

What are derivatives? In a recent *60 Minutes* segment, a securities expert could not explain a derivative handed to him by the journalist. Derivatives, however, are not new, nor necessarily complicated. They are contracts whose value is derived from the value of an underlying asset, such as currencies, equities, or commodities, from an indicator like interest rates, or from a stockmarket or other index. Swaps, forwards, futures, puts, and calls are among derivatives being invented almost daily. Developed as a risk management tool, derivatives allow investors and financial managers to tailor risk profiles, transferring elsewhere the risks they are unwilling to accept.

Why is it important to understand derivatives? The "value" of derivatives depends on the value of the underlying asset, reference rate, or stipulated index. Therefore, it is often difficult to determine what a derivative is worth. One popular measure, known as the "notional value," cites the value of the underlying asset, The notional value of derivative contracts outstanding today is an estimated $16 trillion, i.e., nearly three times the U.S. gross domestic product.

Derivatives players are divided into two groups: dealers and end-users. The latter typically are corporations, government entities, institutional investors, and financial institutions seeking to lower funding costs, enhance yields, diversify sources of funding, hedge, and speculate by taking positions in anticipation of expected market movements. Dealers or sellers of derivatives are mainly banks and securities firms. Critics have pointed out the potential conflict of interest for dealers who are advising investors about purchasing derivatives on the one hand and holding a proprietary position in the same securities on the other.

Attempts at regulation. The Barings PLC and Orange County bombshells and smaller but significant losses have prompted demands for closer scrutiny of derivative markets. Major questions being asked include: Can Barings happen in the United

States? Are derivatives the fault or just the fall guy for bad portfolio and risk management? SEC chairman Arthur Levitt attributed the Barings saga to lax supervision. Echoing similar sentiments, other U.S. officials have questioned the need for additional regulation, although they have suggested the industry should improve risk management and accounting practices.

Part of the problem arises from the fact that derivative investments are largely an "off-balance sheet" item. Since the original transaction creates neither an asset nor a liability until the contract comes due, a company's position in derivatives is not transparent. Some of the major initiatives being implemented as a result of the recent losses require increased reporting by firms of their derivative holdings. The SEC has put out a call for corporations to explain the value of derivative products to their operations and the Financial Accounting Standards Board (FASB) is trying to determine what reporting requirements might make sense. Lawmakers are getting into the act, with at least four bills being introduced in 1994 to address perceived dangers of derivatives trading.

Is more regulation warranted? Added regulation of derivatives markets might be justified if:

- o derivatives posed a systemic threat to the U.S. or global economy, and therefore to United States' national security; or
- o a significant conflict of interest exists between dealers and end-users.

After the Barings disaster, there was a great deal of rhetorical speculation about systemic threats. To date, however, none of the derivatives-based losses have caused more than a slight tremor in national or global financial markets. Individual investors may suffer significant losses in ways that bewilder the layman, but derivatives pose no catastrophic threat to our economy, and thus do not threaten our national security. The more important regulatory issue may be the conflict of interest between the dealer and end-user.

CONCLUSION

Financial services is a strong, vibrant industrial sector in the U.S., one which enjoys significant international competitive advantage based on technological superiority and unmatched powers of creativity and innovation. Without doubt, the centrality of the dollar has declined on international currency markets. The truth is, however, that no other currency is capable of performing the reserve currency function, and no other central bank wants the burden.

Good news aside, this paper has raised at least three clusters of issues and questions that should be highlighted because they warrant the close and continuous attention of strategic policy makers:

o Is America demonstrating adequate financial discipline? Key factors to consider include personal savings rates, the cumulative effect of short-term orientation in America, and the consistency and credibility of Federal Government attacks on the U.S. trade and fiscal deficits.

o Are appropriate safeguards in place to prevent a "meltdown" in the financial industry? Key factors to consider include global financial linkages, volume and velocity of financial transactions, developments in information and communications technology, the need for transparency, and adequate domestic and international regulations.

o Is corporate governance in America adequate to compete in the world economy?. Pertinent considerations include legal changes (e.g., Glass-Steagall and equitable subordination), the impact of technology, and tradeoffs between mass and flexibility.

Governments, industry leaders, consumer advocates, and accounting professionals should all be concerned about these issues and their national security implications. Since all markets--and especially the financial markets--depend ultimately on stable, prudent national entities. Both sovereign governments and "stateless" global corporations have vital interests at stake.

One of our foreign hosts reminded us that "Sovereign governments should be interested in the provision of financial services at reasonable cost and in a context of fiscal stability." It is the latter part of this equation that arose time and again in our visits to U.S. and European financial centers, i.e., the pressing need for America to institute consistent, credible action to ensure long-term financial discipline. Brief spikes of improved performance are not enough. American leaders must alleviate a dangerous reliance on external financing that arises from consumption patterns pursued at the expense of economic opportunities for future generations.

APPENDIX

Financial Training for Military Officers

As the Defense Department and the defense industry continue to downsize, military officers and their civilian counterparts in DoD need improved training in financial management to develop an adequate understanding of the defense industry business. The primary focus of training for military officers should be on comprehending the role the profit motive plays in the private sector.

Although many officers have undergraduate and graduate business degrees, their skills tend to atrophy during their military careers. The Defense Systems Management College (DSMC) offers two helpful hours on financial analysis during its 14-week program managers course; but this is hardly adequate to provide the extensive business education that is needed. Fortunately, this fact is recognized and is currently being addressed by DSMC curriculum adjustments. The Industrial College of the Armed Forces (ICAF) also provides some education and training useful to the understanding the financial health of the defense industry. The elective "An Insider's View of American Industry Today" and the Financial Services Seminar are the most useful elements of the curriculum in providing a foundation. Still, more is needed.

Training needs to be more widespread, with our professional military education programs teaching the basics of financial management to all students. Initial, intermediate, and senior service schools should develop programs that progressively develop the basic skills required for conducting a financial analysis of a defense contractor. Establishing this training at each level of professional military education would ensure repetitive training to the vast majority of military officers. Of all the senior service schools, ICAF is in the best position to generate significant payoffs from such training. Minor changes to its curriculum could pay big returns with the key being additional course work in basic financial analysis skills as part of the core curriculum--not as an elective.

This proposal is not intended to turn our warfighters into businessmen. It simply recognizes that fighting and winning wars is dependent on a strong economy, including a vibrant, responsive industrial base. Military officers especially senior officers working in such an environment, must be able to address these matters intelligently.

ENDNOTES

1. Michael E. Porter, The Comparative Advantage of Nations (New York: The Free Press, 1990), pp 638-39.

2. Japan, specifically, is a victim of the falling dollar. It has worsened conditions in an export driven economy that has been described recently as in a near depression state.

3. However, German debt is largely the product of a one-time effort to unify the former East and West German economies. In contrast to the U.S., both Germany and Japan are financing their debt internally, i.e., they are not dependent on foreign lenders to finance their governments. And, neither of these countries is utilizing debt to anywhere near the same extent as America to finance current consumption. Their long-term debt mostly finances long term investments of presumed benefit to the bill payers.

4. Peter Drucker, The New Realities (Grand Rapids: Harper & Row, 1989), p.115.

5. The Fed's reluctance to reciprocate may stem from two considerations:

o Because of a Congressional propensity to chide the "Fed" as an autonomous power center under the authority of neither the executive nor legislative branches, the Fed's top managers have conditioned themselves and their subordinates not to flaunt their independence. This tendency has resulted in apparent unwillingness to press hard for an overseas presence.

o There is also, probably, a well-defined resistance within the executive branch. But, assuming a continuing goal of U.S. economic leadership, the Fed should not have to rely upon foreign bank representatives resident in the U.S. for information on another country's monetary policy and attitudes. They need their own people on-scene to report on central bank attitudes viewed from the perspective of foreign capitals analyzed in the rich and varied context of local political, economic, and cultural influences. And they need this information in timely fashion directly through their own people to keep pace with the technological developments.

6. Treasury Secretary Rubin, a strong disciple of rational markets, and President Clinton have taken a "talk tough" approach supported by very limited market intervention. On 26 April, members of the G-7 issued a coordinated document stating that the major reason for the dollar's plunge lies in Japan, not in the United States, thereby putting pressure on the Japanese to open domestic markets to imports and stimulate domestic consumption. However, the lack of recommendations for specific actions reflected underlying sentiments that each country (i.e., the United States) must tackle its own problems--budget deficits, low savings rates, and persistent trade

balances.

Another step in this rapidly changing situation (reported by Brett Fromson in an 18 May *1995 Washington Post* article) was taken when regulators from 16 nations agreed on 17 May on a series of steps to increase international cooperation during financial market emergencies and to protect investors' money when it travels overseas. The Barings Bank failure was cited as a wake-up call for regulators concerned that globalization of financial markets has made it more difficult for them to understand and react promptly to crises. Barings raised worries among regulators about how a problem in one market can be transmitted to others far removed from the source of the disturbance. Signatories of the "Windsor Declaration" (the meeting was named after hotel it was held in just outside Windsor castle in London) agreed in this "first step" to promote:

o Increased surveillance of big risks taken by market players.

o Better disclosure of how well customer money is protected by foreign rules and regulations when it ventures abroad.

o Strict accounting by brokerages and exchanges to distinguish client money from brokerages' funds.

o Improved information about bankruptcy laws in each market so investors will know how difficult it may be for them to get their money if their broker fails.

o The establishment by every regulator of a crisis team to provide other regulators with quick information at any time of the day or night.

7. All but silenced in the debates over national and international policy are those who propose a return to the gold standard as the only route to stable, sustained growth and full employment. Returning to some version of the 1792-1971 period when the value of the dollar was related to gold is highly unlikely. Président Nixon's move from the gold standard to fiat money made monetary policy a more flexible tool for decision makers. Critics insist that the shift has encouraged fiscal irresponsibility and lack of discipline because there is no limit to the amount of money a government can issue. However accurately they have fingered the problem, politicians and economists now tend to favor correctives such as a balanced budget amendment rather than a return to the gold standard.

8. John M. Berry and Clay Chandler, "Volatile Money Pool Worries U.S. Officials," *Washington Post*, 17 April 1995, p.1

9. Joel Kurtzmen, Death of Money (Boston: Little, Brown and Company, 1993), pp 235-240.

INDUSTRY STUDY

#12

HEALTH CARE

TABLE OF CONTENTS

PARTICIPANTS

Students

LTC Allan Ballenger Jr., USAF

LTC Matthew W. Cogdell, USAF

LTC Sandra L. Colaw, USA

LTC Kathryn M. Fagan, USAF

CDR Betsy A. Fitzgerel, USN

Mr. Jeffrey Glick, FEMA

LTC John P. Hightower, USA

LTC Michael Jordan, USAF

CAPT Michael J. Miller, USN

COL John H. Moore, USAR

COL Everett W. Newcomb III, USA

LTC Michael J. Reagan, USA

LTC Terry Scherling, ANG

COL Kathleen Srsic-Stoehr, USA

LTC Karl E. Tool, USA

LTC J. Craig Walsh, Jr., USA

Faculty

COL Albert John Sierra, Jr.

Mr. William Knowlton, Ph.D.

Mr. Kim Pendleton

PLACES VISITED

Domestic

U.S. Army Medical Research and Material Command
U.S. Army Medical Research Institute of Infectious Diseases
U.S. Army Medical Material Development Activity
National Institutes of Health
USNS Comfort
Bethesda Naval Medical Center
Uniformed Services University of Health Sciences
Quorum Health Resources, Inc
Cook County Hospital
Baxter Healthcare Corporation
Custom Sterile Division
Round Lake Drug Delivery Division
Distribution Center
Advanced Design Center
V. Mueller Medical Instruments Division
Siemens Medical Systems
University of Pittsburgh
Biotechnology Center
Pittsburgh Cancer Institute
University Medical Center
Transplant Research Labs
Software Engineering Institute
Blue Cross/Blue Shield of Pennsylvania

International

Royal Army Medical College	London, England
British United Provident Association	London, England
Parliament, House of Commons	London, England
Center for Health Services Management	London, England
Siemens AG	Germany
HQ, 30th Medical Brigade	Germany
Hoechst AG	Germany
German Ministry of Defense	Germany
Private Practitioner	Germany
U.S. Army Medical Material Command Europe	Germany
U.S. Embassy	Stockholm, Sweden
Surgeon General of the Swedish Armed Forces	Stockholm, Sweden
Swedish Armed Forces	Stockholm, Sweden
Sodersjukhuset Hospital	Stockholm, Sweden

Astra Pharmaceutical	Stockholm, Sweden
National Corporation of Swedish Pharmacies	Stockholm, Sweden
ADA Pharmaceutical Distributors	Stockholm, Sweden
Pharmacia	Stockholm, Sweden

GUEST SPEAKERS

Mr. Ron Purcell, American Hospital Association
Mr. Leslie Ackerman, Pharmaceutical Research and Manufacturers of America
Ms. Victoria Kader, U.S. Department of Commerce
Colonel Robert A. Leitch, British Military Medical Liaison to the U.S. Army Surgeon General
Commander Gordon Clifford, Canadian Forces Medical Liaison to the U.S. Military
Colonel Susan A. McMarlin, Office of the Assistant Secretary of Defense (OASD-HA)
Colonel Myung Kim, The Joint Staff, J-4-Medical Readiness Division
Colonel Arthur Hapner, US Army 44th Medical Brigade
Colonel James T. Normile III, US Army Medical Material Agency
Commander Dan Snyder, US Navy Bureau of Medicine
Ms. Eugenia Chambers Stoner, University of Pittsburgh
Dr. Murray Goldstein, United Cerebral Palsy Research and Education Foundation

EXECUTIVE SUMMARY

The health care industry is one of the fastest growing and evolving industries in the United States. It is a dynamic, trillion dollar industry that impacts every American in one way or another. Although the U.S. health care system is one of the most technologically advanced systems in the world, there are individual concerns over its cost and equity of access. Issues dealing with cost-effective health care are evident in the marketplace, within government, and among health care professionals. Intense individual concern with quality, affordable health care, rapid technological advances in diagnosis and treatment, governments' responsibility to its constituents, and considerable pressure on providers produce a dynamic, growing, and often confusing environment within the industry.

A complex amalgamation of consumers, providers, governments, and market interests comprise the health care system. There are many players and many competing forces which affect this industry. There are infinite possibilities to exploit for achieving, maintaining, and restoring health. Scientific endeavors and advances in medicine have extended the life expectancy of a U.S. citizen, on average, by nearly 30 years since 1900. The pace of technological breakthrough suggests unlimited potential for significant advances in future years. But, as in any industry, the resources available to exploit these possibilities are finite. Efforts to curb spiraling health care costs and reduce U.S. budget deficits compete with ways to improve access to health care and ensure quality effectiveness. Everyone shares the vision of affordable, universally accessible, high quality care. The challenge is to balance requirements in a resource-constrained environment.

The health care industry was analyzed within three sectors: Health Care Services, Pharmaceutical, and Medical Equipment and Supplies. Guest speakers and visits to various civilian institutions, manufacturing companies, organizations (military and civilian), and governments within the U.S., Canada, Germany, Sweden, and the United Kingdom provided exceptional opportunity to learn and hear first-hand about this vital and evolving industry. The group also gained greater insights into the cultural values and norms which influence a nation's health care structure, infrastructure, human resource needs, and the political influences which attempt to lead these. Student-specific study, reported in individual papers, also contributed to this seminar group's understanding of the industry and implications for the future.

The Clinton Administration's attempt at health care reform through greater government intervention, although unsuccessful in getting Congressional passage, spurred the industry itself to expedite reform by market forces already underway. In the health care services sector, pressure to control costs has led to a greater reliance on managed care programs, a system whereby prepaid plans provide comprehensive coverage to voluntarily enrolled members. Of those individuals now insured,

approximately 68% are covered through managed care programs. Hospitalizing people is on the decline while providing health care through outpatient services and home health care is on the rise as a result of pressures to reduce hospital costs, coupled with significant advances in medical technology.

Shifts in health care settings have also had surging effects on the health care services work force. There are greater needs for primary care providers: physicians, nurse practitioners, and physician assistants. One of the fastest growing work forces and services is in home care.

Consumers are better educated, have higher expectations, and are also older. The older population places a greater demand on our health care system. For every health care dollar in the U.S., 80% is spent on someone who dies within five years. The near-retiring baby boom generation, combined with a slower growth of new workers entering the job market over the next ten years, also contributes to the increasing concern over the viability of government programs such as Medicare and Medicaid. As medical treatment of acute illnesses improves and life expectancy increases, chronic diseases will increase, imposing additional financial burdens upon multiple health care settings.

The drive to control costs will almost certainly lead to an increasingly heated debate on rationing of health care and the use of expensive treatment modalities. Preventive health care initiatives must be increased. However, the acceptance of greater responsibility on the part of consumers for their own health, through partnerships with health care providers, is a key provision to a successful preventive medicine strategy.

The U.S. military health care system is currently under scrutiny following various Congressionally mandated and Department of Defense (DoD) initiated studies. DoD Health Affairs has recently undertaken a major new initiative, TRICARE, as a way to capture efficiencies and cost savings. However, the future of the military medical force structure is uncertain as peacetime and wartime health care requirements and needs are debated.

The pharmaceutical industry is a global market that faces many unique challenges. Many of the advances in the quality of life the world enjoys are possible because of the "miracle drugs" of modern medicine. The cost of these advances are often expensive. The pharmaceutical industry is a high-risk business in which millions of dollars invested in research and development (R&D) efforts may not provide a return on investment. This sector of the health care industry also struggles to keep cost down in today's cost-conscious environment. Third-party payers apply pressure upon manufacturers to obtain price discounts. The demand for generic drugs, rather than more costly brand name drugs, is also on the rise.

The approval process established by the Food and Drug Administration is rigorous and can lead to delays in bringing new drugs to the market. Patent laws attempt to provide a balance between a reasonable return on investment and excessive monopoly profits. Time limitations imposed by these laws and the high cost of R&D lead to what many may perceive as "price gouging." Companies in this industry must deal with this image problem while continuing to seek break through discoveries with new drugs to remain competitive.

The medical equipment and supplies sector of the health care industry is diverse and technologically dynamic with expanding domestic and foreign markets. The U.S. industry has enjoyed substantial trade surpluses. As a market leader among most developed countries, the U.S. remains technologically superior in most medical device categories. U.S. manufacturers are most competitive in implants, in-vitro diagnostics, patient monitoring, and diagnostic imaging equipment. Critical issues facing the industry include government regulatory requirements and industry-wide pressures to curtail rising health care costs.

Technology remains a competitive advantage for the U.S. health care industry overall. However, with today's increasing concern with U.S. budget deficits, the private sector is looked upon increasingly as the source of new research and development. The industry's competitive advantage is protected by patent rights, but under current federal procedures, a firm may have only 6-8 years to achieve profits and recoup R&D investments. Technology in areas such as molecular biology and gene therapy show promise for future treatment modalities. Other technological advances in telecommunications, digital imaging, remote sensing, robotics, medical information, virtual reality, and super computers offer great advances for both civilian and military health care. Technological advances, however, must be measured with improvement in clinical outcomes as the standard of success.

Health care services facilities and medical manufacturing firms alike have attempted to become more efficient and maintain a competitive advantage through mergers, consolidations, and integrated networks, as well as through internal organizational restructuring and quality management initiatives. Medical manufacturing companies are exploring ways to maintain competitive advantage through expanding global markets, partnerships between manufacturing and services, balancing risks in research and development with profitable product lines, and greater customer-driven industry improvements.

As a result of our group's analysis, recommendations for government policy center around specific program reforms, such as Medicare and Medicaid, reducing government red tape regarding patent approval processes and revising anti-trust legislation. In addition, ways to provide incentives for improved access to health care, capitalize upon the cost efficiency of the military health care system, allow market forces to level, and contain health care costs should be implemented.

In conclusion, the analysis indicated that the health care industry remains competitively strong. However, legitimate concerns with rising costs (and pressures to reduce those costs) versus the value placed on advancements in health care technology and health services will continue to drive future activity in all sectors of the industry. Nonetheless, the industry-wide goal remains to balance those costs with the demand for universal access to quality care.

INTRODUCTION

The health care industry is one of the fastest growing and evolving industries in the United States. It is a dynamic, trillion dollar industry that impacts every American in one way or another. Although the U.S. health care system is one of the most technologically advanced systems in the world, there are individual concerns over its cost and equity of access. Issues dealing with cost-effective health care delivery are evident in the marketplace, within government, and among health care professionals. Intense individual concern with quality, affordable health care, rapid technological advances in diagnosis and treatment, governments' responsibility to their constituents, and considerable pressure on providers, produce a dynamic, growing, and often confusing environment within the industry.

The health care industry was analyzed within three sectors: Health Care Services; Pharmaceutical; and Medical Equipment and Supplies. Guest speakers and visits to various civilian institutions, manufacturing companies, organizations (military and civilian), and governments within the U.S., Canada, Germany, Sweden, and the United Kingdom provided exceptional opportunities to learn and hear first-hand about this vital and evolving industry. The group gained greater insights into the cultural values and norms which influence a nation's health care structure, infrastructure, human resource needs, and the political influences which attempt to lead them. Student-specific study, reported in individual papers, also contributed to this seminar group's understanding of the industry and implications for the future.

The purpose of this report is to describe the structure, conduct, and performance of each major sector of the health care industry. In addition, a projected outlook, strategy for industry, and recommendations for government will provide direction for future industry evolution.

HEALTH CARE SERVICES SECTOR

The health care services (HCS) sector is a complex, dynamic, and evolving segment of the health care industry. The primary purpose of HCS is to maintain, improve, or prevent problems regarding the health of people. However, the challenge to the United States world-class, technologically advanced health care services system

is to balance consumer access requirements, contain costs, achieve resource efficiencies, and ensure quality effectiveness.

Structure

Infrastructure. Health care services consist of a variety of public and private (profit and non-profit) institutions and organizations such as hospitals, offices and clinics of medical doctors, and other health care providers (such as nurse practitioners, physical therapists, etc.), nursing homes, and other long-term care facilities. In addition, there are managed care organizations consisting of pre-paid plans such as health maintenance organizations (HMOs), preferred provider organizations (PPOs), and independent practice associations (IPAs). Finally home care agencies and a multitude of other specialized health care facilities or agencies add to the scope of this diverse industry sector.

Market Structure. The HCS sector as a market structure is unique in comparison to other industries. The complexity of HCS and lack of true price information reduces the ability of consumers to make informed decisions without guidance from providers. The entry of providers into the market is heavily regulated. Supply and demand are altered by access inequities, a multitude of compounding escalating cost factors, and lack of consensus about the relationship between the process of providing health care services and the outcomes achieved and/or desired. In addition, third party payers, i.e., private insurers and publicly-funded Medicare and Medicaid, insulate consumers (patients) from assessing price.

Expenditures. Beginning with the increase in federally-sponsored health care in the 1960s, U.S. health care expenditures have increased significantly. In the last 15 years, expenditures have increased over 10% annually. In 1980, expenditures were $250 billion (9.3% of the gross domestic product (GDP)). They have increased to over $1 trillion (14.5% GDP) today. Since 1980, per capita expenditures have quadrupled. The ratio of private versus public expenditures has shifted with the advent of Medicare and Medicaid. In 1970, the private expenditure percentage was 63%, with public expenditures at 37%; whereas, in 1993, private expenditure was 56% and public was 44%. Over 90% of health expenditures are for personal health services with hospital care, physician services, and nursing home care comprising 68% of total expenditures. Non-personal spending includes areas such as administration, construction, and research.

Although escalating cost trends have leveled over the last two years, several factors continue to contribute to the high health care costs: population characteristics (such as the growth of the population over 65 years); the AIDS epidemic; cost shifting --from the uninsured receiving care to the insured who ultimately pay higher coverage rates as a result; technological advances; health spending increases exceeding the general inflation rate; and growth in Medicare and Medicaid program entitlements.

Medicare spending will soon outrun revenues so that by the year 2001, the Medicare Trust Fund will be bankrupt. There is also continual debate over allocation of health care resources for preventive health care throughout life versus more costly treatment near the end of life.

Work Force. Health care is the fastest growing employment area in the economy. There are 10.6 million people that comprise the health care work force, a number that has doubled since 1970. Fifty percent of the health care work force is employed in hospitals, but that percentage is declining as the organization and delivery of health care is restructured and more often based in ambulatory care and home care settings. The highest employment growth rate is occurring in home health care services. The home health aide tops the Department of Labor's list of fastest growing occupations, with a 138% growth projected by the year 2005. Furthermore, the effort to control costs through managed care programs has reduced the need for specialty physicians and increased the demand for primary care providers. Requirements for nurse practitioners, clinical nurse specialists, and physician assistants are also increasing to realistically meet primary care access needs. To contain personnel costs in hospitals, a greater ratio of unlicensed nursing assistant personnel to professional registered nurses is also evolving.

International Comparison. The U.S. spends almost twice as much on health care than most Western European countries. The United Kingdom, for example, spends 6.6% of GDP, while Sweden and Germany spend over 8% of GDP on health care. These countries have national health systems compared to a more market-oriented system in the United States. Although the U.S. spends more on health care, a lower proportion of U.S. citizens have health insurance coverage (85% compared to 100% in the identified European countries) and the average insurance plan provides less coverage than other countries' national health plans. While universal coverage may be lacking in the U.S., emergency care is provided to all, funded largely through cost shifting to the insured and direct federal payment. Consumers in the national health systems must often wait prolonged periods (perhaps up to one year) before treatment (such as non-urgent surgical procedures). Some procedures are rationed. One of the striking observations gained through our group's analysis was the cultural value placed on health, health care, individual responsibility, government regulation, and ethical principles among countries that influenced health care services' systems. Despite the differences in expenditures, access, and cultural mind-sets, most Western European countries are faced with a similar dilemma as the U.S., namely, containing health care costs and determining the value and allocation of health care funding in light of budget deficits and competing resource demands.

Conduct, Performance, Outlook, Strategy for Industry, and Recommendation for Government

Multiple changes have evolved in the system of health care delivery over the last 20 years. Although President Clinton's national health care reform initiative failed to achieve Congressional passage in 1994, the effort did boost action within the industry itself and stimulated other issue-focused legislative proposals currently under consideration by the 104th Congress, such as medical insurance reform, tort reform, and Medicare/Medicaid program transformation. Hospitals and other health care delivery settings have attempted to become more efficient through mergers, consolidations, and integrated network development, as well as through internal organizational restructuring. Pressures to control costs have led to greater reliance on managed care programs, whereby 68% of those now insured are covered through managed care. Hospital inpatient occupancy is decreased due to capitation budgeting, Medicare/Medicaid reimbursement regulations, and medical technological advances, while increases are seen in outpatient diagnostic and surgical procedures and home care services. Today, the consumer is better educated, has higher expectations, and is also older. The older population places a greater demand on our health care system. In fact, 80 percent of every health care dollar is spent on someone who dies within 5 years. In addition, consumers today are shouldering a larger share of their health care costs.

Although there are multiple issues related to the conduct and performance of the evolving health care services sector, there are four major issues which this seminar group considered the most relevant in the conduct and performance of U.S. health care services: (1) escalation of managed care; (2) growth in home care and long-term care; (3) emergence of integrated networks; and (4) the uncertain future of the military health care system. The conduct and performance analysis as well as outlook, strategy for the industry, and recommendations for government for these four issues are subsequently addressed .

Escalation of Managed Care

Conduct and Performance. Managed care, a system of prepaid plans providing comprehensive coverage to voluntarily enrolled members, continues as a growth leader in the health care industry. Managed care plans provide a mechanism to achieve cost controls and predictable cash outlays by selecting (limiting) the physicians and locations (hospitals, clinics, etc.) where plan subscribers obtain medical care and minimizing unnecessary referrals for specialty services. Managed care plans mainly consist of Health Maintenance Organizations (HMOs) and Preferred Provider Organizations (PPOs). Between 1971 and 1991, the number of managed care plans increased from 174 to 553, with enrollment increases from 6 million to 34 million. This represents strong growth and vigorous competition to traditional health insurance indemnity plans in many metropolitan areas.

Managed care corporations and health insurance companies have continually sought assistance in establishing utilization review standards for health care. Review standards help insurers achieve a balance between quality care and cost. Unfortunately, patients and providers sometimes find themselves in the middle and at the mercy of a remote case manager who practices "cookbook medicine."

Outlook. Managed care will continue to dominate the health care market for the foreseeable future. The number of enrollees will continue to grow as federal, state, and local governments and private employers seek to further reduce health care costs. Intense competition will result in an overall decline in the total number of insurers (a trend already beginning) due to mergers, acquisitions, and consolidations.

Strategy for Industry. As the health care industry adjusts to more innovative ways of providing quality care both inside and outside the traditional health care setting, managed care companies must quickly adjust their means of providing coverage to increase their commanding market position. Companies that take advantage of regional community health needs will increase their competitive advantage.

Recommendations for Government. There are several initiatives for government:

(1) Continue efforts to transform the Medicare/Medicaid Program to include managed care options.

(2) Assess the effectiveness and efficiency of TRICARE military health care contracts.

(3) Provide incentives to develop health care purchasing groups for small businesses.

Growth In Home Care and Long-term Care

Conduct and Performance. Two major factors have contributed to an increase in home care and long-term care: reduced hospital occupancy and length of stay, and growth in the aged population. Hospitalization stays are reduced in an attempt to lower costs. Patients are discharged quicker than in the past but still require further care. Health insurers look to cost savings between 40-70% through home care. Medicare and Medicaid reimbursement policies to hospitals also define length of stay limits. Currently 1 in 8 Americans (12.5%) are 65 years or older. By the year 2030, 20% (1 in 5) of the population will be 65 years or older. The increasing percentage of elderly is due to the aging of the post-World War II baby boom population, lower birth rates, lower mortality, and increased life expectancy. In 1993, the average life expectancy was 76 years while 21st century projections average 86 years.

The growth in the aged population has resulted in a population who requires

greater health care needs for acute care and chronic disease management, two of the most expensive elements of health care. Annual growth rate for home care services and residential care facilities such as rehabilitative centers, skilled care, and nursing homes has been 20% over the last 10 years. Given the fast growth in this segment of health care services, the industry is largely unsupervised with ill-defined or non-existent pricing guidelines and limited federal and state regulations for quality control standards. In addition, reform is needed in Medicaid regarding elderly who may have personal assets to pay for home care or nursing home care; but transfer those assets so they can receive federal entitlement benefits. The effects of the aging population also increases demand in the areas of pharmaceutical, medical equipment and supplies, and biotechnology.

Outlook. Our aging population will exert upward pressure on health care costs over the next several decades. With continued increased longevity and a shrinking work force as the baby boomers near retirement age, residential, rehabilitative and home care services' requirements will continue to grow. The industry must continue to search for ways to meet consumers' health care expectations and needs within a cost containment environment. Ongoing development of quality care standards must also be addressed.

Strategy for Industry. There are two major strategies: (1) develop best practices techniques for structuring retirement centers, nursing home, and home health care that incorporate market competition for access, cost, and quality; and (2) develop consumer behavioral change strategies that emphasize individual responsibility for health, yet foster provider to patient cooperative and collaborative relationships.

Recommendations for Government.

(1) Continue efforts to transform the Medicare/Medicaid Program to include managed care options.

(2) Extend Social Security retirement age standard to enlarge the contribution base to and reduce distribution from the Medicare Trust Fund.

(3) Legislate alternatives and options for financing long-term care.

(4) Encourage savings for post-retirement health care through tax incentive programs, such as the development of a Medical Individual Retirement Account (MIRA).

(5) Plan with state governments and professional health care organizations to develop realistic regulations and minimum skill requirements that will address quality control and fraud in home care services.

Emergence of Integrated Networks

Conduct and Performance. Alliances, mergers, consolidations, and integrated networks have emerged in the health care delivery system as strategies to achieve business survival, enhance competitive advantage, and increase efficiency and effective utilization of health care resources. These strategies encompass a variety of health care delivery organizations. In the proprietary sector, large hospital corporations began purchasing hospitals in different markets and instituting centralized and standardized management practices to achieve greater efficiency and profits. Nonprofit hospitals began affiliations with other hospitals in their region of the country to establish guaranteed referral patterns, share services, and for protection against expansion of proprietary chains. Whereas 30 % of hospitals were affiliated in 1979, 45% were in 1987, and up to 80% could potentially be affiliated by the year 2000 if the trend continues.

Regional health care systems are integrated sets of hospitals, physicians, and other providers covering a specific city or region with business plans that offer a full range of services: acute care, physician group affiliations, long-term care, ambulatory services, comprehensive rehabilitative services, home health care, retirement housing, and prepaid contracted and insurance linkages. The goal of these systems is to improve the health status of the population served. Health care services of the future must respond to specific community-based needs through diversification and a continuum of health care delivery. Community-based networks, paid a fixed annual fee per member, provide a seamless system that can maintain high standards of quality and community accountability while delivering care within a fixed budget.

Outlook. Regionally integrated health care networks are the delivery system of the future and will continue to increase and evolve. With a focus on community needs, network providers can better address health issues with schools, elected officials, businesses, religious groups, and other social institutions. Furthermore, they can improve access equity; foster better cooperation and collaboration among health professionals regarding the efficient use of resources; and with a fixed, up-front fee per member, allow resources to more effectively be used for prevention, health education, and community outreach that reduce illness and injury.

Strategy for Industry. Competitive advantage for health care facilities will be attained by those organizations which focus on a broad range of services to meet community health needs and preclude duplication of resources. In addition, integrated networks provide an environment whereby process improvement strategies, such as collaborative benchmarking, can improve clinical practices and administrative and operational procedures.

Recommendations for Government.
(1) Reduce government red tape, e.g., revise anti-trust legislation to allow

legitimate merger and consolidation actions by health care delivery institutions and increase reliance on the private sector to implement health care changes.

(2) Carefully analyze the impact of Medicare and Medicaid spending cuts upon hospital financing needs.

Uncertain Future of the U.S. Military Health Care System

Conduct and Performance. U.S. military medicine faces unprecedented challenges to its structure and functions. This threat comes from both within and from without the military establishment as readiness concerns and conflicts between wartime and peacetime missions are raised. Caring for the approximately 8.4 million Department of Defense (DoD) eligible beneficiaries requires the largest comprehensive health care system in the United States. About 1.5 million, or 20%, of the beneficiary population are active duty military. In an effort to improve access and reduce costs, DoD has initiated a new program called TRICARE which utilizes military facilities, HMO organizations or selected providers, and standard CHAMPUS options as alternatives for providing cost-efficient care for its patients.

Two recent studies, one Congressionally mandated (Section 733, National Defense Authorization Act for FY 1992 and 1993) and another originating in the Executive Branch and Congress (Commission on Roles and Missions), recommended among other options, the reduction of military medical end-strength to 25-50% of its current force levels. Such a reduction would require that most, if not all, nonactive duty patients be referred to the civilian sector for care. The 733 Study found that costs in military health care facilities were from 10-24% lower than those incurred by their civilian counterparts. A problem arises in that by expanding access to military hospitals (which provide totally free care as compared to CHAMPUS, Medicare or third party insurance), an increase in demand would quickly negate the system's cost efficiencies. Both studies offered similar alternatives for the future military health care system structure: (1) continue current system; (2) reduce force to meet wartime mission with some additional structure for selected peacetime care (50% force reduction); (3) reduce the force to meet wartime needs only and privatize peacetime care (75% reduction); or (4) restructure the current system to provide a uniform benefit with reasonable co-payments and deductibles. The future of military health care is yet to be determined.

Outlook. Military medicine must downsize, but in a manner which will ensure its readiness to care for service members in future conflicts. Given the nature of health care, education and training requirements, and career development needs, a structure somewhat larger than wartime requirements is necessary. Care options for other beneficiaries must also be assured. The DoD TRICARE program, as a major new initiative to capture efficiencies and cost savings, must be evaluated closely throughout implementation.

Strategy for the Future and /Recommendations for Government.

(1) Control the demand for services in military treatment facilities (MTFs) through a system of users' fees and/or establish a Military Medical Savings Account (MMSA), wherein contributions to this interest bearing account would be utilized to help offset the cost to service members for the co-payments or fees required for family member use of military health care facilities.

(2) Capitalize upon, not dismantle, the cost efficiency of the military health care system.

PHARMACEUTICAL SECTOR

Introduction

The U.S. pharmaceutical industry is a high-technology industry that is internationally competitive and research-intensive, producing drugs for human and veterinary use. U.S. consumers purchase one-third of all global pharmaceutical. As a world leader in competitiveness and innovation, U.S. manufacturers produce more than half of the pharmaceutical sold world-wide. This sector of the industry plays a vital support role in health care delivery.

Structure

Categories. There are two major categories of pharmaceutical: brand-name and generic drugs. These categories of drugs may be sold over-the-counter (OTC) or by prescription only. Sales of brand-name prescription pharmaceutical surpassed $43 billion in 1993, an increase of 5% over 1992. Sales of generics increased by 20% during the same time frame. The OTC market increased 7%.

Market. In 1990, 9 of the largest 20 pharmaceutical firms in the world were based in the United States. U.S. manufacturers account for nearly half of the major pharmaceutical marketed worldwide. In 1993, the value of all U.S. shipments reached $69 billion. The U.S. pharmaceutical industry is one of the few sectors of manufacturing to record a steady trade surplus. Prescription drug sales placed the pharmaceutical sector among the most profitable industries in the United States.

The market is highly fragmented. Sales of the ten largest companies account for less than 40% of total industry sales. Merck (annual sales $8.5 billion), the largest player in the prescription market, has a global market share of just 4%. The tenth largest company has a share of just over 2%. No one company produces a full range of pharmaceutical products. Profitability (as well as market share) are often determined by the sales of one or two successful drugs in any given company.

The Congressional Budget Office describes the pharmaceutical industry as ***imperfectly competitive***. Firms have competitive power to raise prices and generate profits. But events such as the growth of generic drug use and the collective buying strength of third-party payers are beginning to undermine this power and make the industry more competitive.

Supply and Demand. Despite the highly fragmented nature of the U.S. pharmaceutical market, there are major structural features on the supply and demand sides that impede the functioning of a perfectly competitive market. There are three structural features that shelter firms from competition. First, the diverse nature of drug therapy is one of the primary reasons for lack of seller concentration in the industry. Exposure to all major therapeutic areas is not achieved by even the largest drug companies. Second, managed care programs have attempted to reduce costs through the use of generic drugs, eroding brand-name prescribing and usage loyalty by physicians and patients. Last, widespread coverage of pharmaceutical by insurance and other third-party payers has increased to more than 40% of all outpatient prescription drug expenditures. Patients with insurance are reimbursed, or pay a small fee for the prescription and do not respond to costs as they would if bearing the full expense.

Barriers to Entry. Substantial industry entry barriers for new firms include: (1) high overhead cost of sales and marketing necessary to be competitive; (2) accessibility to markets where drugs are protected by patents; and (3) time and money required to bring new drugs to the market, particularly due to compliance with Food and Drug Administration (FDA) approval processes.

Conduct

Three elements key to the understanding of the conduct of firms in any industry are how prices are set, the impact of government regulation, and trends in research and development (R&D). How these elements are at work in the pharmaceutical industry is discussed below.

Price Setting. Firms in the pharmaceutical sector generally set prices according to the category of product offered, i.e., patent protected, brand name, or generic. Therefore, distinct patterns of price setting exist.

The price of a patent-protected product may or may not be set with regard to competition. Although a company may have a patent for a particular drug, a competitor's product may be available to treat the same condition. In either case, during the period a product is patent-protected, drug manufacturers generally attempt to recoup the cost of R&D that led to the development of the product. In addition to recouping R&D cost, a sufficient profit margin is also sought to offset the high risk involved in bringing a new drug to the market. The majority of pharmaceutical R&D

efforts do not lead to a new product that has commercial potential. Approximately 3 in 10 research items reach the market as products.

In contrast to patent-protected drugs, competition is almost always a major factor in setting drug prices for generic and most OTC medications. This competition often comes from two sources: (1) a brand name equivalent drug; and (2) other generic equivalents. The generic drug must usually be considerably less expensive, e.g., discounts of 20 - 40%, than the brand name equivalent to attract consumers dependent upon the brand equivalent. Price setting policies when compared with other generic equivalents usually allow a closer differential.

Impact of Government Regulations. Government regulations have had mixed effects on the price of pharmaceutical in the United States. Price controls discussed by the Clinton Administration in 1994 as part of comprehensive health care reform had the potential to have a large impact upon the industry. These controls did not materialize. However, as a hedge against price controls and to show that the industry could police itself, price increases were generally less in 1994 than in previous years.

Perhaps the most significant way that government regulations affect prices is in the approval process for new drugs. Many pharmaceutical companies complain that the Food and Drug Administration's approval process for a new drug is too long. They contend that the length of time it takes to bring a new drug to market adds to the R&D cost and contributes to competitive disadvantages in the world-wide market. The FDA has repeatedly stated that it attempts to streamline the process whenever possible; however, definitive testing must be accomplished to ensure public safety. Certain drugs, such as those for the treatment of HIV and AIDS have been the beneficiary of an accelerated approval process.

After patent approval of a new drug, the monopoly granted a company to produce the drug becomes a valuable right that companies strive to protect in the international environment. Benefits from patent rights granted by the Government to manufacture and sell the product generally last for seven years and are usually renewable once for variable periods of time.

Trends in R&D. Approximately 16% of sales of the U.S. pharmaceutical industry are invested in R&D. This compares to the average manufacturing company investment of 3%. The outlays for R&D of major pharmaceutical industries in the U.S. increased five-fold from $2 billion in 1980 to $11 billion in 1992. While successful new drugs are often very profitable, the sales revenues of many new drugs do not even cover R&D costs.

In addition to new product development, R&D efforts may focus on the discovery of new uses for existing products or new and more user friendly ways of packaging existing products (e.g. unit-dose packaging or premixed solutions).

Performance

Two important measures of performance provide additional insights into the pharmaceutical sector: trends in sales and profitability, and international competitiveness.

Trends in Sales and Profitability. Spending on prescription drugs has grown rapidly in the United States. Industry analysts estimate that domestic prescription sales have almost doubled since 1988, reaching an estimated $58 billion in 1993. Since 1980, U.S. spending for prescription drugs has grown at an annual average of 13% (unadjusted for inflation). Although spending on prescription drugs has grown rapidly, it accounts for a relatively small portion (between 4.5% to 6.5% since 1972) of national health care expenditures.

The generic drug segment of the industry is expected to continue growing as more patents on drugs currently in the market expire. In addition, many managed care health providers are prescribing generic drugs as a means of cost control.

Many pharmaceutical industry analysts believe that drug price inflation will slow to 3% to 5%. As a result, annual pharmaceutical industry profit growth, which had averaged 15% to 20% from 1987 to 1991, will moderate to under 10% for the next 3-5 years.

Because of patent protection, conventional measures would suggest that the pharmaceutical industry should be a very profitable one in which monopoly profits generate a high level of return on investment. A closer look shows a moderately profitable industry in which R&D spending, patent rights, and an industry concentration on niche market production in individual companies generate imperfect competition, rather than a monopoly.

International Competitiveness. U.S. pharmaceutical manufacturers are highly competitive and account for nearly half of the pharmaceutical marketed world wide. The large R&D infrastructure and ability to produce new products of high quality are strengths of the U.S. industry. According to one survey, U.S. companies developed 113 of the 265 major globally prescribed drugs that were developed between January 1970 and May 1992. In 1990, 9 of the largest 20 pharmaceutical firms in the world were based in the United States.

The high percentage of sales invested in R&D should help to ensure that the U.S. remains a leader in the international pharmaceutical market. However, international companies based in countries such as Germany and Sweden also invest heavily in research and provide formidable competition.

Outlook

The U.S. pharmaceutical industry is at a crucial crossroads: Will it continue on the high road which has enabled it to become the world leader in developing new and better medicine or will government intervention force American pharmaceutical companies to the low road of slow growth, declining profits, reduced innovation, and bureaucratic control? The U.S. pharmaceutical industry is facing considerable change as a result of price discounting and controls, weak foreign economies, increased use of generic and OTC drugs, and the prospect of increased governmental controls under potential health care reform. To maintain competitiveness, the industry must overcome obstacles such as the lengthy FDA drug approval process and the illegal use of patented and copyrighted products.

Pricing. Although the drug market is expected to continue to expand over the next five years, the industry will face increasing pressure to control prices. Ten of the leading pharmaceutical firms have promised to limit their average price increases to a rate no greater than inflation. Large buying groups under managed care programs will continue to exert pressure for discount pricing.

Cost value of drugs versus other treatment methods must also be considered in assessing drug pricing. Spending $60 per month for a drug that lowers cholesterol may seem high, but not if the alternative is a $46,000 coronary bypass operation. New Hampshire recently made an ill-fated attempt to control the cost of medicine in the state. It limited the number of prescriptions for people on Medicaid. The result was an increase in far more expensive doctors visits, hospitalizations, and nursing home admissions.

Generic and OTC Drugs. An important market trend is the increasing switch from prescription drug status to OTC status. In addition, generic substitutions will increase in popularity as the consumer becomes even more cost conscious. The generic market is expected to increase to more than $21 billion in 1995, as 51 prescription drug patents expire. By the year 2000, due to patent expiration, more than one third of the industry's 300 best selling brand-name drugs many be available in generic form. Managed care organizations embracing the use of generic drugs could cause massive shifts in prescription drug markets and lead to the early demise of some billion dollar brand-name drug monopolies. However, physicians, who have been slow to change their prescribing habits, may offset some of the potential market shifts from brand-name to generic drugs.

Strategy for Industry

There are three major initiatives that can facilitate survival and growth for this sector of the health care industry: (1) restructuring, (2) new product development; and (3) global market expansion.

Restructuring. Faced with sluggish earnings growth, government pressures on

drug prices, and the prospect of major health care reforms, the pharmaceutical industry is beginning to restructure. The restructuring has included efforts such as acquisition and consolidation of other pharmaceutical companies or mergers with biotechnology companies. More brand-name drug firms are also increasing involvement with generic companies, either through acquisition of generic companies, establishing internal generic ventures, or forming partnerships.

New Product Development. Companies will be more profitable with a focus on developing breakthrough drugs, rather than marginal product improvements. Some companies have actually realized more profits from one or two products rather than ten or more. However, companies must sharpen their focus of R&D, constantly balancing R&D investment and operational costs with sales and profits.

Timely Global Market Expansion. Increasing global exports, especially to developing countries like China, Eastern Europe, and Latin America, is another competitive advantage that pharmaceutical companies must achieve. The U.S. pharmaceutical industry is facing stronger international competition. It must overcome international obstacles such as price controls, illegal use of patents and copyrights, and foreign regulations on marketing and R&D. Companies must excel at both research and new distribution methods.

Recommendation for Government

Many within the pharmaceutical industry argue that continued intervention by the Federal Government will force the pharmaceutical industry into slow growth, declining profits, reduced innovation, and bureaucratic control. Conversely, management executives in this industry argue that the real role of government is to support R&D, facilitate a prudent process to field pharmaceutical products, and foster a competitive environment for the industry. The following strategies are recommended for the Government's role in the pharmaceutical sector:

(1) Reform and streamline the FDA patent approval and advertisement regulations to expedite product development to market time while maintaining public safety.

(2) Based on nationally determined priorities for health and health care, support vital R&D efforts through funding to academic research centers and by developing private sector fiscal policies.

(3) Promote market forces to enhance competitive pricing.

MEDICAL EQUIPMENT AND SUPPLIES SECTOR

Introduction

There is a wide variety of equipment and supplies (to include dental) produced in support of health care services. Although the industry can be analyzed specifically within five general sub-categories, this sector of the industry will be reported under one major heading, "medical equipment and supplies." Analysis of this sector identified similarities with the health care services and pharmaceutical sectors in some areas of structure, conduct, and performance.

Structure

Categories. The medical equipment and supplies sector of the health care industry is diverse and technologically dynamic, expanding in domestic and foreign markets. There are generally five multi-tiered sub-sectors, each of which includes manufacturers, packers, and distributors. The five sub-sectors are: (1) surgical and medical instruments; (2) surgical appliances and supplies; (3) dental equipment; (4) x-ray apparatus and tubes; and (5) electromedical equipment. Manufactured products vary widely, ranging from basic equipment (tongue depressors, paper surgical gowns, etc.) to highly sophisticated, technologically advanced equipment (magnetic resonance imagers (MRIs), X-ray tubes, etc.). The finished manufactured products are used to diagnose and/or treat patients.

Domestic and International Markets. Manufacturers of medical equipment and supplies consistently have enjoyed substantial trade surpluses, which rose from $1.6 billion in 1989 to $3.5 billion in 1993. Industry growth increased 8% in current dollar value in 1993, and 9% in 1994. The demand for capital-intensive electromedical equipment, however, had the least amount of growth (1%). Cost-containment pressures and concerns over reimbursement policies adversely affected this tier.

In the global market, exports continue to be the predominant strength of the medical equipment sector. U.S. vendors continue to generate a trade surplus through strong growth in overseas markets. U.S. medical and dental equipment manufacturers continue to be a significant force in the $88 billion global market, supplying 50% of world output in 1994. International demand for U.S. medical equipment and supplies is projected to grow over the next five years from $9.2 billion in 1994, reaching about $18 billion by 2000. Market growth is significant in East Asia, with South Korea leading the way, followed by Singapore, Hong Kong, and China.

Conduct

Several critical issues facing the industry, including government regulatory requirements and industry-wide pressure to curtail rising health care costs, affect the conduct of firms in the sector.

Government Regulation. Government regulation is a significant factor in domestic and international trade markets. Implementation of quality control standards required by the International Organization for Standardization has increased U.S. manufacturers' costs, but has ironically also placed U.S. firms in a more competitive sales position in the global market. That is because U.S. regulations, which help implement the international standards, also require all equipment to be approved by the FDA. Despite sometimes lengthy approval processes, some international markets more readily accept U.S. products for their high quality and safety.

The FDA is also participating in the Global Harmonization Task Force which includes government and industry representatives from the U.S., European Community, Canada, and Japan. The purpose of the task force is to develop internationally accepted quality standards for medical devices.

Product Development/Cost/Value. High technology medical equipment is developed and produced in an effort to provide better quality "service to the customer." At every step of the process of developing, marketing, maintaining, and operating an innovation more dollars are added to the overall cost of health care. The cost of developing sophisticated, technologically advanced products forms an entry barrier to some firms which might otherwise find the equipment market attractive. With new, complex equipment comes the need to train more specialized, and generally, more highly paid operators. Sophisticated technology and the development of new equipment results in time-saving, accurate machines but at an extremely high cost to diagnose and treat health problems. For example, the price for position emission tomography (P.E.T.) equipment, which performs discrete whole body imaging, ranges from $1 to $5 million. There are only about 78 P.E.T. scanners in the U.S. (mostly at research centers), despite its value in sophisticated early diagnosing capability.

Competitive Advantage. Medical equipment and supplies firms are constantly looking for new ways to become more competitive, cut overhead, protect market shares, and provide better health care to their consumers. They are also looking for ways to reduce costs, or at least control them. Like many other industries, downsizing and price competition continue as goals within the sectors. To achieve these competitive goals, constant improvement in quality, teaming, partnerships with suppliers, automation, and efficiency is a must. With manufacturing centers located throughout the world, the sectors are indeed multinational. Developing assembly centers world-wide rather than assembling the final product at the manufacturing

center has increased international competition.

Our study included visits to representative medical equipment corporations, domestic and foreign. The major corporations visited have gone through significant downsizing; however, many were able to place employees elsewhere within the corporation to improve production. Despite overall restructuring, employment in this sector of the industry increased by 287,000 in 1994.

All corporations were heavily involved in R&D to improve the quality of their products. Total quality management techniques are evident throughout the industry. Employees help to make decisions and changes, and they work as a part of a successful team, rather than on traditional assembly lines. This process improvement allows for customizing the product and improved quality at reduced costs. Additionally, the use of automation, robotics, and other technology advancements have improved production and product quality. There is also a growing interdependency of businesses in these sectors. Equipment parts and components are manufactured in plants around the world and shipped to the final assembly site, demonstrating the global nature of the industry.

Performance

Cost Efficiency. Health care industries worldwide are under pressure to increase their cost efficiency. The medical equipment and supplies sector has been one of the best performing U.S. industries. Progress in areas such as optical tomography, imaging, and laser technology will most likely improve U.S. competitiveness in advanced medical equipment. Optical tomography has the potential to save lives and cut costs, especially in the area of breast cancer. With continued improvements in high-definition digital imaging transfers, physicians will increase their ability to exchange information and knowledge, make diagnoses more rapidly, and enable surgery which might otherwise by impossible.

As managed care programs increase, control of costs is shifting from vendors to purchasers. For example, equipment and supply firms are facing negotiations with purchasers regarding pricing for reusable versus disposable supplies. In an effort to curtail costs, some purchasers are requesting refurbished equipment rather than more costly "hot off the press" models. Developing countries in Latin America, Eastern Europe, and Asia are also emerging as the fastest growing destinations for this equipment.

Outlook

U.S. as Market Leader. U.S. leadership in medical education, research, and practice, as well as in computers, biochemistry, and other related fields, has nurtured the U.S. medical equipment sector's competitive edge for decades and is expected to

continue. Of the 20 largest medical equipment and supplies firms in the world, 13 are American. U.S. manufacturers are most competitive in implants, in-vitro diagnostics, patient monitoring, diagnostic imaging equipment, and other high-tech devices. Japanese and German firms are the strongest competitors with the U.S. in these market segments, while manufacturers in developing countries (e.g., India, Brazil, and China) are a growing force in low-tech market segments.

Capable of fulfilling the broad spectrum of medical technology needs, U.S. medical equipment companies will continue to have the largest overall market share and produce a trade surplus.

Curtailing Costs. Complementing increased sales, medical equipment and supplies companies have steadily reduced sales and administrative expenses. Many companies had maintained large sales forces that were once necessary for marketing to thousands of hospitals and physicians. Now, with many hospitals consolidated, the need for such large sales force efforts has diminished.

Historically, a large share of medical products used in diagnosis and treatment were prescribed and controlled by physicians. Today and in the future, cost-containment measures are shifting the purchasing power from physicians to third party payers who are now driving many purchasing decisions.

International Competitiveness. In international competitiveness, the average annual real growth for U.S. surgical and medical instrument shipments is predicted to range between 6-7% through 1998. As cost-containment pressures dictate reliance on less-invasive surgical procedures that reduce risk of complications, hospital stays, and labor costs, the demand should rise most rapidly for instruments and equipment used in minimally invasive surgery such as internal stapling devices and laprascopic and endoscopic instruments. Ongoing initiatives with countries throughout the world such as NAFTA, the zero-for-zero tariff initiative under the Uruguay Round of the General Agreement on Tariffs and Trade (GATT), and the U.S.-Japan Framework Agreement will also assist the industry and increase sales by reducing trade barriers and enhancing market access.

Advanced Technology. New health care information systems are offering a new market for computer systems used in health care. These systems are utilized in a variety of ways from monitoring patients in an intensive care unit, providing telemedicine consultation, assisting with robotic surgery, or even keeping track of financial billing. The worldwide market for computer systems dedicated to medical applications is expected to grow at a 10% annual rate through 1996. These new technologies in medical applications will maintain the U.S.' leading edge into the 21st century.

Strategies For Industry

Apply Health Care Cost Containment Measures. Sharply rising health care expenditures have induced private sector and government health care purchasers to emphasize cost effectiveness in medical technology acquisition. This dynamic has already affected medical markets and will continue to do so regardless of the outcome of any proposed health care reform.

Customizing products, supporting refurbished equipment demands, consultation services, servicing agreements, developing other partnerships, and conducting advanced engineering prototyping are means that firms should continue to use in response to cost pressures.

Develop Global Market Expansion. The largest markets for U.S. medical devices are in developed economies such as Japan, Canada, Western Europe and the U.S. itself. These markets are sufficiently wealthy to demand high volumes to support quality health care equipment. However, the fastest growing demand for medical devices is found in high growth East Asian and Latin American countries, where per capita incomes are approaching levels allowing significant upgrading of health care delivery systems. While developed countries remain by far the largest customers for U.S. medical equipment, and will remain so for several decades, exports to developing counties should be exploited.

Participate In Ways to Harmonize Approval Regulations and Standards. Concern over delays in FDA processing of product approvals and export requests have influenced corporate decisions on location of research and manufacturing facilities abroad. While apparent progress at FDA resulted in faster approvals and reduced backlogs by the end of 1994, the impact of regulations on research and development will certainly remain a major concern of the U.S. medical device industry.

Disparities between U.S. and foreign regulations have resulted in duplicative testing and approvals for U.S. medical equipment products. Harmonization of regulations and standards is of growing concern, as many developing countries which previously relied heavily on imported medical products and foreign regulatory agencies are establishing their own medical industries and regulatory regimes.

Recommendations for the Government

Recommendations for the government are similar as those for the health services and pharmaceutical sectors:

(1) Reform and streamline the FDA product approval process to expedite

product development to market time while maintaining public safety.

(2) Promote market forces to enhance competitive pricing.

(3) Reduce government red tape, e.g., revise anti-trust legislation to allow legitimate and competitive mergers and consolidations.

(4) Support research and development efforts in the area of telemedicine for both civil and military applications.

(5) Investigate issues and initiate possible tort reform for product liability laws.

CONCLUSION

Health care plays an important role in the physical, psychological, and economic well-being of every American. Maintaining, improving, or preventing health problems are the primary activities and ultimate goals undertaken within the realm of the U.S. world class and technologically advanced health care industry. The dynamics of the U.S. population's health problems, availability of resources to meet those needs, continued technological breakthroughs, and the organizational and financial elements of the system affect the structure, conduct, and performance of the overall industry. The outlook for the industry is promising, despite legitimate concerns with rising costs and pressures to reduce those costs versus the value placed on advancements in health care technology and health services. The industry-wide goal remains to balance costs with requirements for universal access to quality care, and that goal can be strengthened by a cooperative and collaborative partnership of responsibility and accountability on the part of American citizens, providers, industry, and government.

REFERENCES

Aday, L.A., C. E. Begley; D. R. Lairson; C. H. Slater, Evaluating the medical care system, Ann Arbor, Michigan: Health Administration Press, 1993.

Author Unknown, Drug producers await health care reforms, Chemical Week, 1994.

Bast, J.L.; R. C. Rue; S. A. Wesbury, Why we spend too much on health care. Chicago: The Heartland Institute, 1993.

Congressional Budget Office. Chapter Two, Industry and market background, A CBO study: how health care reform affects pharmaceutical research and development, 1994.

Edwards, M., Medical Devices Industry Analyst, U.S. Department of Commerce. Telephone information update 18 May 1995.

Information Access Co (1994), Pharmaceutical industry fundamentals undergo change: 1994 chain drug review state of the industry report: industry overview. Chain Drug Review. 16(9):62

Longest, B.B. (1994). Health policymaking in the United States, Ann Arbor, Michigan; AUPHA Press/Health Administration Press.

Terry, D. (1994), Integrated health care in California's managed care capital. Managed Care Quarterly, 2(4): 24-34.

U.S. Department of Commerce (1994), U.S. industrial outlook.

Wagner, L. (1995), Can we make a new deal?, Hospitals & Health Networks, 69(2): 24-28.

Weber, J. (1994), Drugmakers are discovering the high cost of cutting costs, Business Week, October 17, 1994.

Weidenbaum, M. (1994), The U.S. pharmaceutical industry at a crossroads, Executive Speeches, June/July 1994:83-87.

--------. (1995). Regulatory agenda: medicare and medicaid update, From Vision to Action, American Hospital Association.

------. (1995), Barriers to forming community health networks, From Vision to Action, American Hospital Association.

------. Numerous newspaper and magazine articles (NY Times, Washington Post, Wall Street Journal, Business Week, etc.) kindly provided throughout the semester by Mr. Kim Pendleton, ICAF faculty.

------. Industry Study papers submitted by the Health Care Industry Seminar students. Selected topics included: managed care, HMOs, home care, long term care, prevention, benchmarking, advanced technology, military health care, aging, population, and tort reform.

INDUSTRY STUDY

#13

LAND COMBAT SYSTEMS

TABLE OF CONTENTS

PARTICIPANTS

Students

Mr. Gary Anderson, D/A

LTC Chuck Baker, USA

BG Aboubakr Bakr, Egyptian Army

LTC Dan Bonney, USA

LTC Ann Dunwoody, USA

BG Steinar Huse, Norwegian Army

LTC Daniel Imholte, USA

COL Jiri Javurek, Czech Republic Army

Ms. Rosalie Jordan, D/A

Ms. Shirley Lemon, D/A

LTC Tom Lytle, USMC

LTC Randy Martinez, USAF

LTC Mark Swanstrom, USMC

LTC Jose Vazquez, USA

Ms. Gail Willey, D/N

Faculty

COL Paul Severance, USA

Dr. Jim Currie

LTC Bob Garcia, USA

PLACES VISITED

Domestic

U.S. Army Night Vision Lab	Ft. Belvoir, VA
United Defense Limited Partnership	York, PA
Beretta International	Accokeek, MD
Letterkenny Army Depot	Chambersburg, PA
Saturn Corporation	Spring Hill, TN
Oshkosh Truck Company	Oshkosh, WI
AM General Corporation	South Bend, IN
U.S. Army Tank and Automotive Command	Warren, MI
General Dynamics Land Systems	Detroit, MI
Lima Army Tank Plant	Lima, OH
U.S. Army Test and Evaluation Command	Aberdeen, MD

International Travel

Steyr-Daimler-Puch Spezialfahrzeug AG	Vienna, Austria
Krauss Maffei	Munich, Germany
GIAT	Versailles, France
Vickers Defence Systems	Newcastle on Tyne, England
Royal Ordnance	Nottingham, England

GUEST SPEAKERS

Mr. Charlie Cutshaw, USMC Intelligence Activity, Quantico
Mr. Chuck Sieber, OUSD (A&T)
MG Michael S. Davison, Jr., USA, Commander, Army Security Assistance Command
Mr. Jim O'Bryon, Deputy Director of Operational Test and Education
MG John E. Longhouser, PEO, Armored Systems Modernization
Mr. Eric Orsini, Deputy Assistant Secretary of the Army Logistics
GEN Don Starry, USA (Ret)
COL Joseph Yakovac, PM Bradley Fighting Vehicle Systems

"A horse! a horse! My kingdom for a horse."

Richard III, V:4
Shakespeare

INTRODUCTION

The focus of this and every other Industry Study is to eliminate the potential for anyone wearing a U.S. uniform today from re-living King Richard's experience, from finding himself on the battlefield improperly equipped or inadequately supplied. That impetus compels that this year, perhaps like every year before it, the focus of the Industries Study phase of the ICAF curriculum is bound to change. These changes are not so much the result of the students' desire simply to differentiate their work from that of their predecessors, but more potentially indicative of changes taking place in the world that impact the industries we study.

As we examined the world of Land Combat Systems, we were reminded that the U.S. Army had decided under the auspices of its *Force 21* initiative to examine the soldier, his equipment, and weapons as a system. Current research and development in the areas of communications, digitization, and enhanced warfighting capabilities so complicate the individual soldier's environment that the Army is dealing with him as a system. In that regard we thought it reasonable for us to pursue the same train of thought and at least expand our focus to include small arms in our study. Perhaps next year's group will want to investigate the Army's initiative--the soldier as a system--in greater detail.

That was one small example in an environment that is turbulent and dynamic beyond prediction. But no single initiative has had a greater impact on this industry than the peace dividend. No matter who you talk to, the same words keep winding their way into conversations and are common to the vocabulary of those who have spent a bit more of their lives focused on land combat systems than we have. Downsizing, restructuring, Total Quality Management, the list goes on and on. But the distinct impression is that everyone--government officials, management, and workers--are well aware of the new rules of the game--the new rules that say get smarter, leaner, produce higher quality, lower costs, and become more efficient in the way you do business if you want to survive.

Finally, as you examine our report you will find the general subject of Land Combat Systems divided into three categories: wheeled vehicles, tracked vehicles, and small arms. And although each category may differ slightly in content, each addresses the state of the industry, the impact of trends and policies on national security, and the economy.

TACTICAL WHEELED VEHICLE SEGMENT

Segment Description

Tactical wheeled vehicles (TWV) are the backbone of any land combat force because they are as key to success on the battlefield as the combat vehicles and forces they support. They transport personnel, equipment, petroleum products, critical supply items, ammunition, food, water, and combat casualties, and are called upon to perform their missions across any terrain their combat counterparts occupy. They are also prime movers for command, control, communications, computers, and some weapons systems. Because of the design adaptability, many systems are built on platforms that form the core of a vehicle family.

If a land combat force is to remain viable as an integrated force, then a continual effort must be made to modernize, upgrade, and replace the TWV fleet to make sure its capabilities are equal to those of the combat vehicle fleet they support. As the prime movers for supporters and sustainers, the TWV fleet must be able to traverse the terrain and distances of their supported forces and at speeds that allow them to perform the full spectrum of their missions.

Typical design requirements for the TWV fleet are:

- Satisfy a full range of mission requirements
- Overmatch any potential adversary
- Enhance rapid deployment
- Perform effectively worldwide in all terrains and climates
- Provide maximum reliability
- Require minimum maintenance support
- Provide crew/vehicle protection where required.

Core Competencies

The core competencies of the tactical wheeled vehicle segment of land combat systems are largely shared with the domestic automotive industry in terms of required skills for workers and assembly techniques. And unlike their armored cousins, design and requirements of tactical wheeled vehicles are much less subject to change or dependence on threat capabilities. One need only examine the current TWV fleet with its forty-year-old designed "deuce-and-a-half " to find supporting evidence for this. Additionally the current 2.5 ton being rebuilt by A.M. General proves that off-the-shelf parts can, with very little modification, satisfy a military requirement.

Global Market Trends

It is difficult to make any distinction between the domestic and world-wide trends in this segment of the industry. As the Soviet bloc dissolved, all Western Governments have taken steps to reduce the size of their armed forces. This changing strategic environment has reduced product demand, and the race is on for the remaining military and larger commercial market share that resides in the civilian sector. Companies most likely to survive in the TWV industry are those with an existing market share vested in the civilian sector and the innovation to capture more of that business.

American Capabilities

Structure. The major manufacturers of tactical vehicles are:

- AM General Corporation*
- Oshkosh Truck Corporation*
- Freightliner Corporation
- Stewart & Stevenson Corporation
- Hagglund Corporation

*Manufacturers visited

Of these manufacturers, AM General, Oshkosh, and Stewart & Stevenson manufacture trucks; Freightliner primarily manufactures trailers and has recently partnered with Oshkosh. As a result of the unique requirements for TWV, these manufacturers specialize in military products, but have different levels of involvement in the commercial market. Oshkosh's line of fire trucks, snowplows, and cement trucks provides a commercial outlet for their products; AM General is trying to enter the commercial market with a commercial variant of the HMMWV.

Another point of interest is that these manufacturers are integrators and assemblers. For example 70% of the parts in Oshkosh products are provided by second-tier manufacturers. Although some of these second-tier suppliers are foreign companies, our inquiries over parts availability during periods of national emergency did not raise anxiety levels from corporate leadership. Additionally, many of the second-tier manufacturers are tooled to produce only the specific military parts required by a major manufacturer. None of the sources consulted had any information that would allow for an assessment of the impact of low production rates on second-tier manufacturers. We can only assume that spool-up times estimated by the manufacturers take second-tier manufacturers into account.

Mobilization Capabilities. None of the manufacturers considered in this study are using their production lines at anything close to maximum capacity. In some cases current demand has production lines used as little as ten percent of maximum.

Major assemblies are available from existing manufacturers or from easily adaptable commercial designs.

Foreign Competition. The long-standing preference for American manufacturers to supply the vehicles for the U.S. Armed Forces remains today. But the Army's move to award the Family of Medium Tactical Vehicles (FMTV) contract to Stewart & Stevenson, a subsidiary of Steyr of Austria, clouds the water for favoring purely American companies, and serves as a portent for the future of U.S. manufacturers. For those whose only customer is the U.S. Government and who lack a sufficient segment of the commercial market to survive without government purchases, the future is bleak. Foreign manufacturers long ago weaned from the government's trough have secured sufficient market share through strategies that put their American competitors at a great disadvantage.

Classification. The family of tactical wheeled vehicles is classified as light, medium, or heavy using the following weight class criteria:

* **Light Fleet**: Vehicles <2.5 tons. Currently they are:
    - Commercial Utility Cargo Vehicle (CUCV)
    - High Mobility Multi-Purpose Wheeled Vehicle (HMMWV)

* **Medium Fleet:** Vehicles 2.5 tons through 5 tons.
    - M35 Series 2.5 tons
    - M939 Series 5 tons
    - M809 Series 5 tons
    - Family of Medium Tactical Vehicles (FMTV)

* **Heavy Fleet:** Vehicles > 5 tons. Currently:
    - Heavy Expanded Mobility Tactical Truck (HEMTT)
    - Heavy Equipment Transporter System (HETS)
    - Palletized Load System (PLS)
    - M915 Series Line Haul Tractors
    - M916 Series, Light Equipment Transporters
    - M920 Series, Medium Equipment Transporters

Performance Standards. The performance requirements for tactical wheeled vehicles are what distinguishes them from commercial variants and prohibits purchasing existing commercial designs. When one considers the requirements for all-terrain trafficability, reliability, capability to fit inside several different types of aircraft, and multiple adaptations for every design, one begins to understand why there are no readily adaptable designs from the commercial sector. Other significant differences are:the ability to negotiate 60% slopes and 30-40% side slopes, high engine power, multiple driven axles, operational requirements from -50 to +120 degrees Fahrenheit, 24 volt systems, and chemical resistant painting. The basic

characteristics impose design differences that begin with the tires, work their way through the suspension, and encompass the entire vehicle.

Issues

Current Fleet. The current fleet is barely adequate. The two major problems with it are: age of the fleet and outright shortage of critical items. The medium vehicle fleet is primarily composed of the well known deuce-and-a-half that was brought into the inventory about 25 or more years ago. The average age among the 2 1/2 ton fleet is 23 years; some 5 ton trucks are over 40 years old! Annual maintenance costs are estimated between $6,000 and $8,000 per year. If these expenses were to remain constant, in 12 years the maintenance costs will equal the cost of a new FMTV. Best estimates now are that the U.S. Army will not begin replacing them until 2010.

The HMMWV fleet is already approaching its first decade and will probably need replacing about the same time, if not sooner. Liberal estimates are that this will happen between 2005 and 2010. There are 75,000 HMMWVs in current military service. The 15,000 HEMTTS currently in service will mature at these same dates.

Funding. Overall the TWV budget is declining. Between 1993 and 1995, allocations were 41% less than projections. For FY1995 the Navy projects no TWV requirements and the Air Force projects a $2.2M expenditure. The Army is the primary customer with $382.7M projected for this FY95.

Initially the Army's modernization plan called for purchasing 120,156 new trucks over a 15-year time period. Reduced budgets and greater competition for funding in a constrained environment extended the purchase period to 30 years, which raised the price per unit from $72,000 to $134,000. Anticipated force reductions compelled new calculations which reduced the required numbers to 102,050 then to 87,598. The Army awarded its first five-year contract to Stewart and Stevenson for 10,873 FMTV trucks, with an estimated price per unit of $91,000. Last year the Army removed $1.25 billion from the FMTV program from FYs 1996 through 2001. Later they cut additional dollars from the FY1996 funding.

The Extended Service Program (ESP). As an interim fix, the Army awarded A.M. General a contract for rebuilding 2 1/2 ton trucks in 1993. The initial contract called for 2,608 trucks to undergo the process at a cost of $57,000 per unit, 61% of a new FMTV.

Impact On Industry

AM General, whose sole focus is the manufacture of the HMMWV, is probably most at risk. They have produced a civilian variant that is available through a dealership network, but at an entry price of $62,000 per copy, commercial sales cannot possibly replace lost government revenue, therefore foreign military sales and replacement of the current fleet are necessary to keep AM General in business.

While we were visiting AM General, plans were in place to release 200 of their most junior employees within the next month if no new contracts were obtained. More senior employees would be transferred from the HMMWV assembly line to the ESP project and their salaries accordingly reduced.

Our perspective is that while the HMMWV is a tremendous vehicle and an asset to land combat forces, reducing production or ceasing it all together would only have a serious impact for AM General's ledger books. Although their assembly line has only one automated station, the required skills are not that difficult to come by among UAW members.

Oshkosh's specialty is manufacturing extremely specialized vehicles for the military and commercial markets. The military segment at one time was over 80% of their business, but that number is nearing 60% and going down. Although impacted by a loss of military contracts, Oshkosh will not go under or close its doors.

Stewart & Stevenson is an Austrian-owned company which has been in the business of building military vehicles for some time now. In fact the Army pursued the FMTV as an attempt to buy an existing design with minor modifications to meet U.S. military specifications.

That program got off to such a shaky start once teaming got underway, full-scale production was delayed and currently Stewart & Stevenson is producing FY1993 requirements. Fifth year funding of the first five-year contract was cut from the FY1996 budget.

Conclusion

Production Capability. This Unite States' TWV production capability is concentrated in three manufacturers, only two of which are at risk without military contracts. The only critical resource lost if production closes down at any of these facilities is time--the spool-up time needed to re-start the line. Support for two nearly simultaneous major regional contingencies could be in jeopardy.

Upgrading the TWV Fleet. Until the problems with the FMTV can be sorted

out, the DOD should continue sufficient production to keep the line warm. Estimates of shortages for the current fleet to meet transportation needs are as high as 20%. When you factor-in the maintenance and reliability problems caused by the age of that fleet, the readiness and capability problems are readily apparent, and place at least the support slice for the two MRC scenario in serious jeopardy. Both funding and production need to be pursued relentlessly.

ARMORED COMBAT VEHICLES SEGMENT

Segment Description

An armored combat vehicle is uniquely defined by its ultimate purpose: to engage in or directly support land combat. The conditions of ground combat dictate that each vehicle possess a unique blend of survivability, mobility, and function. Survivability is achieved primarily by use of steel, aluminum, or composite armor systems. However, increased survivability incurs weight penalties that will reduce mobility and/or capability. Global sales competition within this segment is based on combat effectiveness of each system, its ability to contribute to national security objectives. While cost must be considered, each nation wants combat capabilities equal or superior to its perceived opponents.

Core Competencies

The core competencies of the armored combat vehicle industry focus on the unique skills required to compete in the world market place. While many of the components and production skills are similar to the automotive industry, civilian vehicle manufacturers cannot produce an effective armored combat vehicle. Combat systems concepts are uniquely based on threat and technology projections. System design and integration must incorporate developing technologies, weapons, and their supporting sub-systems, and determine the vital trade-offs between survivability, mobility, and function. Production engineering faces fabrication of unique materials and part sizes under strict quality standards at relatively low production rates while maintaining production efficiencies. Continued reliance on ballistic welding requires a relatively skilled work force. While capital barriers to market entry are high, specific engineering and production skills are directly transferrable to the civilian automotive industry. As a result, government support, through production assistance, R&D funding, or purchase contracts is required to sustain each nation's domestic industry.

Global Market Trends

Recent trends in the global armored vehicle industry mirror the perceived changes in the strategic environment at the end of the Cold War. The traditional Western powers have reduced their own requirements for active forces and have not yet identified a significant survival threat which would require replacement of their

current armored vehicle fleets. Significant quantities of near state-of-the-art surplus vehicles are available, while the Western powers have reduced current production quantities and research and development of future systems. State supported industries in Russia, China, France, and South Africa continue to compete aggressively for the remaining demand for new first-line systems, centered primarily in the Middle East. Without an unforeseen change in perceived threat world wide, demand for armored vehicle systems will continue to decline with continued downsizing of the armored vehicle industry. Existing manufacturers will remain dependent on government support for their continued existence and attempt to maintain market share using three primary strategies:

- Application of additional cost control measures

- Development of incremental heavy system product improvements: defensive systems, armor enhancements, and on-board data systems

- Design of specialized niche combat vehicles: internal security variants, amphibians, command and control vehicles, and rapid deployment systems.

American Capabilities

Structure. The domestic armored combat vehicles industry is dominated by two manufacturers: United Defense Limited Partnership (UDLP) and General Dynamics Land Systems (GDLS). Both rely on continued production orders by the Federal Government as their core market and augment income where possible through direct or government brokered overseas sales. In response to the expected reduction in demand, both companies have downsized significantly but continue to retain significant excess production capacity. Despite cost control efforts, unit costs continue to increase due to the overhead associated with excess capacity, increasing technological sophistication, and reduced order quantities. In this environment, neither company can afford the investment to fully modernize its production lines; therefore, process improvements are incorporated only when cost effectiveness is demonstrated. Compared to automobile plants, production remains relatively labor intensive with automation incorporated primarily to support environmental and safety concerns and improve process quality. Neither company is structured to compete in other than development, design, and production of armored combat vehicles.

UDLP Market Position. UDLP was formed in January 1994 by integrating FMC's Defense Systems Division, the sole source for the Bradley Infantry Fighting Vehicle, and Harsco Corporations BMY Combat Systems Division, the traditional source for self-propelled artillery systems, including the M109 and ammunition supply vehicle, and numerous other low volume niche vehicles. This partnership leaves UDLP as the only current domestic supplier of medium to light armored vehicles. With the exception of the Paladin program, all production is conducted in contractor owned

and operated facilities. The Paladin upgrade teams UDLP and Letterkenny Army Depot; the depot tears down and refurbishes M109 chassis components while UDLP assembles and integrates new turrets at a leased facility located on the Letterkenny.

Through labor force downsizing, supplier base management initiatives, and other cost control efforts, UDLP appears to be well positioned for the near-term with system upgrades on Bradleys, Recovery Vehicles, and M109A6 Paladins in progress. The company's ability to produce several low volume vehicle types simultaneously, incorporating common subsystems and components, remains its principle advantage. Future viability is contingent on continued program support for the Advanced Field Artillery System (AFAS), now dubbed "Crusader," which is the only funded new U.S. Army system being developed. UDLP is the team leader on the current $1 billion demonstration and validation phase contract.

GDLS Market Position. General Dynamics bought Chrysler's Defense Division in 1982 to form the nucleus of the current Land Systems Division. General Dynamics retained this division and its nuclear submarine operations as industry leaders while less competitive divisions were sold. GDLS is the sole producer of the Abrams main battle tank, Abrams upgrades to M1A2 specifications, and the Abrams- based Heavy Assault Bridge. All production is based at the government owned, contractor operated Lima (Ohio) Army Tank Plant. In addition to vehicle production, GDLS is under contract to maintain plant facilities and surge capability. While cost control efforts have been very effective, downsizing of the GDLS workforce is expected to continue as current Abrams upgrades and FMS package production near completion. The current production rate already falls far below the 170 tanks per year required to retain global market competitiveness. In the near term, management is focused on measures that will allow production of 120 tanks per year despite continued reductions in appropriations. Both GDLS and the Army's Program Executive Officer believe a rate less than 120 cannot support a viable supplier base.

While GDLS is teamed with UDLP to develop significant elements of Crusader, initial production will be well beyond the year 2000. With production of a new tank not anticipated until 2015, GDLS continues efforts to define an Abrams system upgrade, known as "Tank 1080," but a valid requirement for this system has not been approved. Assuming GDLS can survive the lean years of the late 1990s, GDLS may compete against UDLP for future U.S. orders. GDLS strategy is to retain its technical edge in heavy vehicle production, expand the Abrams derivative line, compete for new products focusing on the Advanced Amphibious Assault Vehicle (AAAV), and grow the combat information systems business. Long-term survival of a warm domestic tank production base as currently structured probably hinges on GDLS gaining the lion's share of AAAV production or convincing the government of a need for a "Tank 1080."

Key Suppliers. The supply of several critical unique components for the industry are already sole-sourced. These components include large caliber cannons

(Watervliet Arsenal), depleted uranium armor components (Department of Energy), tank engines (Stratford Army Engine Plant), and recoil systems (Rock Island Arsenal). Long term government support for these facilities is essential if the U.S. is to maintain a viable domestic production base. Inclusion of the Stratford plant on the FY95 base closure list is indicative of DOD's lack of a clear vision of the future of the armored combat vehicle industrial base. The number of smaller component suppliers continues to shrink based on low expectations of future segment growth and declining profitability as production runs become smaller. While not yet at a critical level, loss of this supplier base could greatly increase the lead times for future production and degrade quality of future combat systems. While acquisition reform initiatives hold some promise reducing supplier costs, these initiatives alone are unlikely to sustain the supplier base over the long term given the lack of projected production contracts until 2015.

Mobilization Capabilities. Current production facilities have sufficient capacity to respond to mobilization and reconstitution tasks associated with the two regional conflicts scenario. As the current armored vehicle fleet ages, consistent supplies of spares for legacy systems will be increasing difficult to procure; Detroit Diesel has already announced its intention to end production of Bradley engines. Significant increases over current production levels will require at least 18-24 months to procure long lead-time items and assume availability of skilled labor from the automotive industry. From a cold base it is estimated that a minimum of five years would be required to reconstitute the industry to its present level.

Foreign Competition

Faced with economic pressures similar to those in the U.S. industry, and a need to upgrade their forces to capabilities equal to the Abrams benchmark, foreign tank manufacturers are aggressively marketing their products. Germany's Krause Maffei with the Leopard II A5, and France's Giat, with the LeClerc, offer comparable performance at lower cost with greater financial and co-production flexibility. Russia's T-90E, with its second generation reactive armor, may provide the most cost effective capability, but Russian marketing skills have yet to exploit its sales potential. Besides new tanks, most development efforts focus on system upgrades to extend the life of obsolescent tanks by applying improved fire control, armament, and powertrain packages at relatively low cost.

Greater diversity typifies the light to medium armored vehicle market. Specialized armored vehicles, either tracked or wheeled, are available to meet virtually any tactical need from both traditional and emerging military suppliers. Dispersion of production capabilities without regard to international borders is no longer exceptional; offsets, joint development projects, co-production, and international teaming are commonplace. European manufacturers, faced with relatively small domestic requirements, lead the U.S. in applying these cost and risk sharing methods.

While U.S. manufacturers focus on maintaining outright leadership in production, European firms are somewhat more diversified. The percentage of value added by the system integrator is smaller and production rates for existing orders can be sustained at very low levels. The European companies are much less reluctant to diversify into related industrial segments to provide a fallback when production orders wane.

Issues

Cost Growth. Unit costs for armored combat vehicles continue to increase at an unprecedented rate. Trends toward smaller production runs, increasing technical sophistication, and pursuit of leading edge capabilities are unlikely to change. Linear incremental improvements in performance will also generate exponential cost growth. To partially offset this trend, DOD must intensify its efforts to improve the cost effectiveness of programs. Acquisition reform and dual use solutions may improve the situation somewhat, but the unique military nature of the armored vehicle industry limits their impact. Unique teaming arrangements, up-front planning for life extension and product improvements, horizontal technology integration, and common component engineering can improve industry performance. Historically, international co-development efforts have only succeeded when several countries identified an identical urgent requirement. With a reduced survival threat, positive steps to encourage international system developments will share risk and cost, improve system performance in the absence of fierce domestic competition, and strengthen current alliances.

Prime Contractor Consolidation. Given excess U.S. industrial capacity, further consolidation to a single supplier of armored combat systems is a distinct possibility. Assuming the remaining supplier continues to operate the Lima plant, a single supplier can meet anticipated production demand and mobilization needs. While current domestic competition is limited to two suppliers with somewhat different skills, this limited competition, coupled with joint cooperative oversight as a result of Crusader teaming, has provided cost cutting incentives. A single prime contractor could meet requirements, but lacks incentives to improve efficiency and foster innovation. In this eventuality, DOD should encourage more direct competition from reliable NATO sources and co-development projects to retain industry vitality.

Supplier Base Contraction. In a declining market, reductions in the supplier base are inevitable. Except for GFE items, DOD lacks visibility of the supplier base below the first tier. Current prime contractors have the technical and business skills to more accurately project the status of their supplier base and identify critical production levels. In addition to ensuring continued availability of unique GFE items, DOD must support the recommendations and cooperative efforts of the prime contractors with regard to their supplier base. Failing this risks both near-term product quality and

long-term production capability.

Conclusion

Despite many recent studies, DOD has yet to develop a coherent vision for the future of armored combat vehicles. The central issue in the armored combat vehicle segment remains: "Does America require the domestic capability to design and manufacture the premier armored combat systems in the world?" Not withstanding visions of a remote control, third wave ground conflict, something remotely resembling a main battle tank and armored supporting systems will probably remain dominant forces through at least the mid-21st Century. If the United States believes merely competent systems will do, these can be procured most economically from either foreign or domestic sources on the open market based purely on cost effectiveness decisions when increased capabilities or quantities are required.

Continued technical superiority and assured availability demands a coherent plan to sustain armored vehicle development programs on a continuous basis. Full exploitation of opportunities for efficiency is more likely if concepts are incorporated into an armored vehicle master plan. Free market forces will not assure the survival of the domestic production base, let alone qualitative or quantitative superiority. While detailed planning and increased efficiency can sustain the industrial base at the minimum level, only continued funding for current production efforts coupled with increased research and development efforts on future systems will assure competitiveness on the battlefields of the future.

SMALL ARMS SEGMENT

Segment Description

Small arms are vital weapon systems that touch virtually every soldier. While not all soldiers will operate wheeled or tracked vehicles, each will be issued a rifle, many will use machine-gun type weapons, and some will be issued pistols. The Army's Small Arms Master Plan (4th Revision) defines small arms as: "Weapons and munitions used in direct fire engagements, portable by a dismounted individual or crew of two, for the purpose of defeating personnel and suppressing enemy weapon systems." Increasing focus on the conduct of military operations other than war has fueled renewed interest in small arms effectiveness. All major powers, as well as many smaller countries, produce a variety of small arms that are widely available on the world market. Competition in the marketplace is based primarily on weapon performance: weight, accuracy, sustained rate of fire, reliability, and ease of maintenance are the key combat effectiveness measures. Innovation is incremental with major changes limited by existing ammunition standardization agreements.

Core Competencies

Key elements of the small arms industrial base include facilities, production equipment, technical data packages, and personnel with specific technical knowledge and skills. With the possible exception of barrel manufacturing, production methods are similar to other industrial segments that produce precision machined steel parts. Design of small arms must consider unique environmental and field service use by relatively untrained operators. Production engineering must ensure absolute reliability while providing a capability for mass production of interchangeable assemblies. Perhaps the most vital element of the manufacturing process is the technical knowledge, skill, and expertise of the people performing the work. Specific experience in the design and manufacture of small arms is considered critical to the industrial base. Retention of the technical and engineering capability requires experience in actual weapons manufacture. Low-volume production of current items as well as development of prototypes applying continuously improving state-of-the-art technology may be the only way to retain surge capacity.

American Capabilities

Structure. The domestic small arms industrial base has eight commercial firms providing core new production. All new weapons are manufactured in contractor owned and operated facilities although some firms continue to use government owned machine tools. These firms are: Sigarms, Beretta, Mossberg, Remington, Diemaco, Colt's Manufacturing, Saco Defense, and FNMI. The last three are the major producers of military small arms (other than pistols). Of these three, only Colt's Manufacturing has a significant commercial small arms business. Primary government industrial base activities are Anniston Army Depot (depot overhaul) and Rock Island Arsenal (repair parts manufacture). Weapons currently in use by the U.S. military include: 9MM M11 subcompact pistol, 9MM M9 automatic pistol, 5.56MM M16 series rifles, 5.56MM M4 carbine, 40MM M203 grenade launcher, 5.56MM M249 SAWS, 7.62MM M24 sniper rifle, 12 gauge M590 shotgun, 7.62MM M240 light machine-gun, 7.62MM M60 light machine-gun, .50 caliber M2 heavy machine-gun, and the 40MM MK19 grenade machine-gun (GMG). Over 50 firms have provided recent support either in improvement programs or in design and development of new weapons. There are also many small businesses involved in manufacturing repair parts.

Mobilization Capabilities. Production capacity far exceeds current requirements and anticipated needs in support of a two MRC scenario. Survival of two of the current major producers would be adequate to support any mobilization requirement. Except for the M4 carbine, the Army owns the technical data packages (TDPs) for production of small arms. However, manufacturing processes are not specified in the TDPs. Restarting production or a change in production location could adversely affect reliability and production rates. While facilities could be reestablished if allowed to close, such action would take time; from a cold base, establishment of

mass production capability may require 18 to 36 months. Consequently, industry representatives generally advocate continuous production to exercise all aspects of the process to retain the needed expertise.

Issues

Funding Fluctuations. DOD budget projections for small arms have seen a dramatic decrease in the past four years. Total resources for production, overhaul, repair parts, and R&D declined from nearly $140 million in FY 92 to a projected $29 million in the FY1996 budget submission. Each major producer estimates that $20-$30 million is required to support continued economic viability. Projected funding levels are inadequate to support the current industrial base and to complete acquisition of weapons required to fully equip the force. Shortages of the M4 carbine, MK 19 GMG, and the M249 SAW continue. Decreased funding may reflect a combination of changes in requirements related to downsizing and the fact that most weapons have reached their respective acquisition objectives (AO). This poses the issue of how best to maintain a capability to produce additional weapons for those systems that are still below their AO, support the current weapons in the field, and continue to explore new and improved designs for the small arms of the future.

Industry Consolidation. With limited available funding, reductions in the number and capacity of small arms producers are inevitable. Cost-effective reductions can initially be achieved solely through reliance on market forces. Current demand could be met by a single manufacturer. However, DOD must decide what minimum capability must be retained, particularly in production of machine-guns and automatic grenade launchers, and establish a strategy to support this capability. If a domestic small arms industry is vital to national security, two competing major producers conducting low rate production and R&D efforts are sufficient. Contracts with these suppliers must include maintenance of an adequate surge capacity and support and service of fielded systems. Retention of a limited emergency capability in the arsenal system will provide adequate mobilization capacity and a hedge against uncertainty. Approval of multi-year funding to support this minimum capacity is essential to the long term health of the industry.

Conclusion

The small arms industry is currently faced with difficult choices. Capacity far exceeds demand or expected orders; downsizing is just beginning. If the consensus of Congress, the Executive Branch, and the DOD is that the small arms industry is critical to the national security strategy, then DOD must lead in defining how the future industrial base should be structured. Without question, market forces will drive several current companies away from the military market in the very near future. Only a coherent plan linking R&D investment, production orders, surge capacity and the role

of the depots will ensure continued viability of the domestic small arms industry over the long term.

SUMMARY

The land combat systems industry is a microcosm of the broader defense industry and is impacted by the same forces. Under pressure from reduced spending, significant downsizing has occurred but capacity remains greater than current or projected requirements. While our study examined several key segments of land combat systems in some detail, it was far from comprehensive. Intelligence, command and control, artillery, troop support, communications, and air defense systems are but a few of the segments that also warrant examination but were not covered this year. Regardless, some general conclusions about the future of land combat systems can be drawn from the three segments covered in our study.

Taken in isolation, each segment appears to require government intervention to sustain industrial capacity. But it is precisely this myopic view that results in "salami slice" funding decrements, continuation of unneeded programs, and sustainment of excess capacity. Acceptance of uncertainty and change has never been the strong suit of the military-industrial complex. Sometimes, the dire predictions of the time and money needed to reconstitute defense-related industries are based on reestablishing full Cold War capacity and not necessarily on the requirement to support two short duration regional conflicts. To make matters worse, most predictions are made by manufacturers with vital interests at stake. Despite the negative prognostications, can we imagine a circumstance where a fully-funded program to produce large quantities of trucks or carbines would not attract several competent bidders within the vast and diverse American industrial base? Assuming continued resource reductions, government support of every industry segment would lead to future unreadiness as surely as a laissez-faire approach. Therefore, identifying critical skills, competencies, and capacities is merely the first step in deciding a viable policy. In this new environment, we must improve our ability to select and support only those industry segments that are truly essential to attaining national security objectives and which will not be commercially supported at a level from which we can reconstitute.

Land combat systems will remain a key element of national military power for the foreseeable future. Incremental system enhancements continue to be developed and fielded world wide. Of the segments we studied, only the armored combat vehicle industry meets the criteria for continued production support without an operational imperative. While we have recommended specific actions to reduce future uncertainty in both the wheeled vehicle and small arms segments, a failure to carry out these recommendations will not have significant national security implications. Domestic commercial capacity, offshore availability, current inventory levels, and process commonality provide an adequate hedge against future uncertainty.

In armored combat vehicles the situation is quite different. Sustainment of parity, let alone superiority, requires continued application of R&D funding to design combat systems that can win the conflicts of the future. Future battlefield superiority will not be the least costly option. Continued low rate production is necessary to field cost effective operational enhancements, maintain unique production skills, and support a supplier base for unique components that are not commercially available. While armored vehicles may only be munitions delivery systems in the age of information based warfare, their relative capabilities could win, or lose, the next major conflict.

INDUSTRY STUDY

#14

MUNITIONS

TABLE OF CONTENTS

PARTICIPANTS

Students

COL Dennis P. Duplantier, USA (Student Seminar Leader)

LTC James Callender, USAF

LTC Michael Catlin, USAF

LTC Thomas Darner, USAF

CDR Robert O. Kedney, Jr, USN

Ms. V. Gail Lankford, D/A

LTC Peter B. Mack, USA

LTC James A. Neumeister, USAF

COL John R. Pinnel, USAF

Ms. Janet M. Reardon, DLA

LTC Gerard W. Schwartz, USA

LTC Clarence G. Summerlin, USAF

LTC Michael D. Williams, USAF

Faculty

LTC Marcus R. Erlandson, USA (Faculty Seminar Leader)

Mr. William F. Jones, FEMA

COL Donald W. Taylor, USAF

PLACES VISITED

Domestic

Aeronautical Systems Center	Eglin AFB, FL
Atlantic Research Corporation	Gainesville, VA
Hughes Missile Systems	Tuscon, AZ
InterContinental Manufacturing Company	Garland, TX
Loral Vought Systems	Grand Prairie, TX
U.S. Army Missile Command (MICOM)	Huntsville, AL
Naval Surface Warfare Center, Dalhgren Division	Dalhgren, VA
Sandia National Laboratory	Kirtland AFB, NM
Texas Instruments Defense Systems & Electronics Group	Lewisville, TX

International

United Kingdom Ministry of Defence	London, United Kingdom
British Aerospace, Bedford	Bedford, United Kingdom
British Aerospace, Stevenage	Stevenage, United Kingdom
Federal Republic of Germany Ministry of Defense	Bonn, Germany
U.S. Embassy	Bonn, Germany
Aerospatiale	de Magny les Hameaux, France
French Ministry of Defense	Paris, France

GUEST SPEAKERS

Brigadier General William Holmes, USA	Deputy Chief of Staff, Ammunition
Mr. J. David Wilson	Former Congressional Staffer, Defense Subcommittee, House Appropriations Committee
Rear Admiral Charles Beers, USN	Deputy Assistant Security of Energy
Dr. Victor H. Reis	Assistant Secretary of Energy for Defense Programs, Department of Energy
Mr. Harry Schulte	Program Executive Officer for Conventional Strike, U.S. Air Force
Dr. John Goodman	Deputy Assistant Secretary of Defense (Industrial Affairs)
Mr. John Fedor	Director of Congressional Relations, Alliant Techsystems
Mr. Jack Thalhimer	Principal Manager of Munitions Programs, Alliant Techsystems
Mr. Paul Blumhardt	Director for Studies and Analyses, Lockheed Martin Corporation

INTRODUCTION

The munitions industrial base represents critical and unique industrial capabilities required for U.S. national security. There are no civilian or commercial markets for the products of this industry--the company sectors providing these products and capabilities rely completely on defense markets for survival. Except for limited small arms ammunition and some demolition explosives, the Department of Defense (DoD) is the sole U.S. consumer for this industry. DoD must ensure changes in the munitions industry environment do not put vital warfare capabilities at risk. This report outlines the industry itself, its changing environment, the future, and recommendations for industry and government to ensure this future is successful.

Definition of the Munitions Industry

The munitions industry covers a broad spectrum of products ranging from simple small arms ammunition to highly sophisticated guided missiles and precision guided munitions (PGM). These product can be segmented into three broad categories:

- Ammunition
- Missiles and precision guided munitions (PGMs)
- Weapons of mass destruction (WMD)

Product Segments

Ammunition. Products in the ammunition group contain some type of energetic material (explosives, incendiaries) and are unguided after they are fired. Historically, these products have been relatively unsophisticated and usually produced on high volume mass production lines. DoD segments ammunition end items into 14 subsets:

Pyrotechnics (flares, signals
Small caliber (5.56 mm, 7.62 mm, .50 caliber)
Cannon caliber (20 mm, 25 mm, 30 mm, 40 mm)
Artillery (105 mm, 155 mm)
Bombs (MK82/83/84, BLU109/110/111)
Mortars (60 mm, 81 mm, 120 mm projectiles)
Dispenser munitions (combined effects munitions--CEM)
FASCAM (family of scatterable mines, including ADAM, RAAM, and GEMSS)
Navy gun (3-inch/50, 76 mm, and 5-inch/54 families)
Tank (105 mm and 120 mm)
Rockets, warheads (HYDRA 70, AT, and SMAW)
Propelling charges (artillery, mortar, and Navy gun)
Demolition, grenades, and mines
Fuses (electronic, mechanical)

Ammunition items today are becoming increasingly sophisticated, employing highly intelligent fuses and penetrators constructed from advanced materials. Given the ever increasing accuracy of modern guns and launch mechanisms, and the rapidly rising cost of the more sophisticated ammunition items, there is a movement away from large-scale mass production in this sector.

DoD has designated the U.S. Army as the single manager for conventional ammunition (SMCA). Within the Army, the U.S. Army Industrial Operations Command (IOC), under the Army Materiel Command (AMC), overseas the procurement and production of ammunition for all the Services.

Missiles and PGMs. Products in the missiles and PGM group are technologically sophisticated, intensively managed, generally high cost systems that are often produced at low production rates due to their complexity and higher costs. These products often contain in-flight guidance systems and are usually subject to long production lead times. The cost of these munitions routinely exceeds $10,000 per round, and can exceed $1 million per round.

A missile is a space-traversing unmanned vehicle. It contains a propulsion system usually consisting of rockets, and often a guidance system that has the means of controlling its flight path. Examples include:

• Air-to-air missiles (Sidewinder)
• Air-to-surface missiles (Hellfire, Maverick)
• Surface-to-air missiles (Patriot, ERINT)
• Surface-to-surface missiles (TOW, ATACMS)
• Cruise (Guided missile employing aerodynamic lift and propulsion whose flight path remains within the earth's atmosphere, such as the Navy Tomahawk cruise missile)

The PGM segment of the industry is comparatively newer and still being defined. One proposed definition of PGMs is munitions (or submunitions) that can discriminate and guide to their targets, or can orient themselves to fire on their targets. An alternative definition limits PGMs to devices that are adaptations or extensions of conventional ammunition, launched by conventional means and encompassing weapons originally termed "smart", "intelligent", or "brilliant", such as munitions that can seek autonomously for targets once they have been delivered into the target area. In either case, examples include:

• Sense and Destroy Armor (SADARM). Army sponsored, artillery delivered guided submunition using millimeter wave and infrared (IR) sensor. Production pending.
• Brilliant Anti-Tank (BAT). Army sponsored, rocket delivered submunition using acoustic and IR sensors. Under development.
• Sensor Fused Weapon (SFW), known as SKEET. Air Force sponsored, aircraft delivered submunition using millimeter wave sensor.

• Wind Corrected Munitions Dispenser (WCMD). In production.
• Joint Direct Attack Munitions (JDAM). Joint Air Force/Navy Program employing a kit containing a guidance control unit with GPS to convert 1000 and 2000 pound bombs to inertially guided munitions. In EMD by two competitors.

Weapons of Mass Destruction (WMD). WMD include nuclear weapons, chemical weapons (CW), and biological weapons (BW). The U.S. does not currently produce any of these weapons. The U.S. destroyed its stockpile of BW prior to the ratification of the Biological Weapons Convention (BWC) in 1975. This international treaty outlaws production and use of BW. The Chemical Weapons Convention (CWC) forbids the production of lethal CW and required the destruction of all CW stocks and production facilities.. The U.S. signed the CWC in January 1993. Senate ratification hearings are currently in progress. DoD, under Congressional direction, is currently destroying its chemical weapons stockpile and production facilities. The U.S. continues to maintain a stockpile of strategic and tactical nuclear weapons. While the U.S. will maintain a capability to produce nuclear weapons, its inventory of nuclear weapons has been reduced, with the entire stock of ground-launched tactical weapons scheduled for demilitarization. The Department of Energy (DOE) is responsible for developing, maintaining, and disposing of nuclear weapons.

Ownership Structure and Level of Concentration

The munitions industrial base includes a combination of government owned/government operated (GOGO), government owned/contractor operated (GOCO), and contractor owned/contractor operated (COCO) facilities each with different management and contractual arrangements. Government owned facilities play a prominent role in the production of ammunition and WMD.

Government-Owned/Government-Operated (GOGO) Facilities. The U.S. government owns and operates three major ammunition production facilities, a reduction from six GOGO facilities that existed in 1978. The three remaining GOGO facilities are designated Specified Mission Facilities (SMF) and deemed critical because of their unique production capabilities:

• Crane, IN: Navy gun projectiles, demolition charges, pyrotechnic devices, warheads, Rockeye, 155 mm and 165 mm projectiles.
• McAlester, OK: bombs, Navy propelling charges, 20 mm and 40 mm cannon rounds, 5" rockets.
• Pine Bluff, AR: smoke, thermal, and incendiary munitions.

In addition to these three facilities, the government retained the Hawthorne, NV facility with no current production mission.

•Government-Owned/Contractor-Operated (GOCO) Facilities. Like GOGOs, GOCO facilities generally are involved in performing hazardous operations necessary for the production of ammunition, such as the manufacture of explosives and propellants and load, assembly, and pack (LAP) operations. There were 26 active GOCOs in 1978; there are only six in active status today. These six are designated as Group Technology Centers:

• Holston, TN: explosives.
• Iowa, IA: missile warheads, tank and high explosive artillery LAP, demolition charges.
• Lake City, MO: small caliber and 20 mm ammunition.
• Lone Star, TX: loaded components, improved conventional munitions (ICM) artillery, FASCAM, hand grenade LAP.
• Milan, TN: 40 mm grenade, tank, artillery, and fuse LAP; mortars; demolition charges.
• Radford, VA: propellants.

In addition, the government has retained 12 additional GOCOs in an inactive status to provide emergency capability.

Contractor-Owned/Contractor-Operated (COCO) Facilities. In 1978, there were 148 COCOs with Plant Equipment Packages (PEPs) and 138 without PEPs within the ammunition sector. A PEP is a set of government-owned production equipment. In 1995, there are 19 COCOs with PEPs, an 87% reduction, and 33 COCOs without PEPs, a 76% reduction. This large decrease in the number of COCOs was a result of consolidation of numerous, small, specialized contractor ammunition lines that could not be supported by decreased U.S. procurement of ammunition. The remaining plants in this sector produce a wide variety of products, and each type of product requires a distinctive production process.

Final integration of missiles and PGMs takes place only in COCO facilities. The competing firms are relatively large, diverse companies producing extremely sophisticated high-technology products. Their plants are generally highly flexible manufacturing facilities.

Concentration. The ammunition sector is currently composed of dozens of major producers, most of which are COCOs, and many more supporting suppliers. The COCOs include eight prime system contractors and 88 sub-contractors. This segment of the munitions industry is highly competitive. The top four companies account for about 40% of the market share. The largest of these receives 100% of its revenues from defense sales, and has 14% of the market share. The top 24 companies accounted for 88% of the market share. The ammunition segment of the market has the capability and will produce some PGM-like munitions, such as the Smart Target Activated Fire and Forget (STAFF). STAFF is a direct fire, 120 mm tank bullet, where a

person-in-the-loop puts it on target.

The missile and PGM segment of the munitions industry is characterized by very large, complex, and diverse firms. Of the U.S. missile-producing firms that reported production in 1994, six of them were the top six defense producers in the U.S., and two of those top six producers have now merged. The missile prime contractor base has drawn down from eleven to five. The PGM prime contractor base has halved itself, consolidating from 14 firms to 7. Much of this reduction has been through consolidations and mergers. Although remaining firms publicly see themselves remaining in the business, further reduction is likely, with only four or five prime contractors surviving. The reduction in second and third tier subcontractors is even more severe.

The decline in the number of PGM producers and critical subcontractors will create a serious problem in responding to a large mobilization effort. Also, the production rate for this level of technology is very slow and limits any surge capability. The munitions industry of the future must be able to respond aggressively with accelerated acquisition programs in order to conserve costs and meet unique requirements. Development of the GBU-28 during DESERT STORM was a prime example of this type of development and acquisition process. The GBU-28 was a smart bomb designed to penetrate hard targets. Composed of several components from other common munitions, the system was developed, tested, and fielded in only 6 weeks and performed its designed mission during the last day of the war.

Clustered Industries. The munitions industry is clustered with numerous other industries, among them air, land, and sea combat systems, electronic components, optics, electro-mechanical systems, search and navigation equipment, guidance and control systems, propulsion systems, and computer (hardware and software) systems.

Unique Characteristics of the Industry. This industry has a broad range of salient characteristics distinguishing it from other industries:

- Unique--no commercial counterparts
- Monopsony--DoD is the sole buyer
- Essential for readiness and sustainment
- High capital investment required
- Long lead times for production
- Limited production
- Extremely hazardous materials
- Extensive land requirements for testing
- Environmental implications

When these characteristics are integrated, it's readily apparent market forces alone cannot sustain this industry. To ensure national security, DoD must act to ensure this industrial sector is preserved.

Buyers. Except for limited small arms ammunition and some demolition explosives,

DoD is the sole U.S. buyer for this industry. The National Military Strategy (NMS) provides the framework for determining wartime requirements for munitions. For nearly half a century, U.S. military strategy focused on fighting a global war against the Soviet Union and Warsaw Pact. With the collapse of the Soviet Union in 1990, the NMS shifted from a global focus to one of fighting regional conflicts. Articulated in DoD's Industrial Capabilities for Defense, September, 1994, "This strategy requires a force structure sized and equipped to deter, respond rapidly, and, if necessary, fight and win two nearly simultaneous major regional contingencies of limited duration. U.S. forces must have the ability to project rapidly a ready force capable of fighting and fully sustaining itself in any theater of operation with little warning. Each of the armed services is required to have enough ammunition in stock (and prepositioned in the right locations) to fight and win these regional conflicts. Ammunition is to be drawn from existing stockpiles while fighting the regional conflict. After the conflict, stocks are to be replenished to a specified level--in-kind, modernized, or with reasonable substitutes--within a specified period of time." This strategy implies no opportunity or intent to mobilize the industrial base during a conflict. However, the U.S. did not completely fight DESERT STORM with only the stockpile of munitions on hand, even though that stockpile was developed to enable the U.S. to fight a global war. Rather, some key production lines went into operation around the clock, 7 days a week, to provide the most advanced munitions capabilities to U.S. fighting forces. Now, in FY 95, the latest strategy is to maintain a stockpile sufficient to fight two MRCs and then, after the fighting is all over, replenish enough ammunition for one MRC.

The change in threat has created a requirement for a new munitions strategy for DoD and its supporting industry. Today's strategy and budget can no longer afford a capability or capacity that supports munitions production beyond current war reserve and annual training levels. The Defense Planning Guidance (23 May 1994) states: "The Department will promote a strong, technologically advanced industrial and technology base able to develop, produce and support advanced military systems in a cost effective manner." Based on this guidance, the ammunition community developed the following strategy verbalized in the Industrial Operations Command's Ammunition "State of The Base:"

> Production capacity retention levels for ammunition are based on peacetime and replenishment demands. The ammunition industry must be able to replenish ammunition stocks depleted during a conflict within a specified time frame after the conflict. At the same time, the industry must be able to meet peacetime ammunition requirements for war reserve munitions and training munitions. Therefore, a responsive ammunition industry is required that can meet both of these demands simultaneously.

Barriers to Entry. Munitions production requires large capital investments in equipment and large land areas for manufacture, storage, testing, and disposal of muni-

tions. The industry requires specialized skills for handling and processing its hazardous materials. This industry is subject to stringent production safety requirements and security regulations. The industry creates potentially dangerous environmental hazards, and is subject to demanding environmental compliance. In most instances, DoD is the sole domestic buyer; U.S. demand has been decreasing; and the Export Administration Act restricts exports to potential international buyers. International demand for U.S. products has also been declining as foreign competitors emerge. The declining U.S. demand and U.S. trade restrictions are perhaps the most discouraging barriers to new American companies entering the munitions market.

INDUSTRY CONDUCT

Market Structure—Industry's Response to a Changing Market

Due to decreasing demand conditions and budgetary constraints, the munitions industry is experiencing intense competition for the increasingly scarce production dollars. Winning or failing in competitions for contracts can and has spelled the difference between surviving or disappearing from the market place altogether, as dozens have already left. In 1988, the ammunition sector alone employed about 90,000 people; 82% of that work force is now gone. U.S. industry has expressed a concern that it can lay away the equipment and facilities, but it cannot lay away the skills. Furthermore, it typically requires 36 months to restart a munitions production line that has been cold for more than 6 months.

Munitions companies have responded to the reductions in procurement by downsizing, restructuring, consolidating, or by leaving the market place altogether. Reductions in munitions procurements have encouraged consolidations, particularly in the missile and PGM segment. A recent merger resulted in formation of the world's largest defense firm. Thirty thousand jobs are expected to be lost in that merger, however.

The ammunition segment of the industry sees itself in crisis. As a result, 18 of the largest producers formed the Munitions Industrial Base Task Force, a consortium to focus attention on the industry's problems and to seek more favorable legislation, including increased procurement of ammunition products.

Government Policies and Regulations

Government policies and practices have a direct effect on the health of the munitions industry and its ability to respond to DoD needs.

Requirements Determination. Since the end of the Cold War, DoD has found it increasingly difficult to clearly and accurately define the threat and hence, the resultant force structure and weapon systems required to meet that threat. The munitions requirements process has felt the impact of this requirements dilemma. Requirements

determination for munitions is important but highly complex. Despite powerful computer simulation, it's still pretty much a black art. Each service has its own unique and independent methods to determine the type and quantity of munitions needed. Additionally, inputs from many diverse sources like the warfighting CINCs, non-DoD federal agencies, and even Congress, further complicate the process. Moreover, past efforts to force jointness and interoperability have been less than successful. Roles and missions often overlap and the debate rages on if this overlap is necessary. A typical repeatedly asked question is "How many different ways do you need to kill a tank?" Another debate centers around the requirements for new advanced.delivery platforms versus more affordable PGMs. Both are necessary, but there appears to be no clearly articulated policy outlining the proper priorities and mix.

Annual Funding. Annual funding allows political adjustment and causes turbulence for munitions programs, just as in other sectors of the defense industry.

Best Value Contracting. Recent government initiatives to base source selections on "best value" versus lowest bid has caused concern and distrust in some segments of the munitions industrial base.

Commercial Practices. Government procurement policy has begun to embrace commercial standards and practices. This approach has seen success in the munitions arena. The best example is the JDAM program, where this approach has driven down costs while promising to deliver an effective weapon for the warfighter.

New Management Techniques. Partnerships with contractors, suppliers, customers, technical activities, and other government organizations are being tested throughout the industry. Such techniques have demonstrated significant material and overhead cost reductions through cooperative industry and government efforts.

Joint/International Program Challenges. Munitions, by their very nature, lend themselves to employment from a wide variety of platforms operated by different services and nations. Despite this, varying funding and valid unique requirements make joint and international programs difficult. The recent cancellation of the Tri-Service Standoff Attack Missile (TSSAM) reflects the difficulty of making joint programs work.

Stockpile Utilization. The recent decision to use stockpile ammunition to meet training requirements further reduces annual U.S. production. This cost-effective way to reduce the stockpile has its down side. Ammunition production requires specialized skills that are gained mainly through experience. Preserving these skills during low production runs remains a formidable problem for the munitions industrial sector. The SMCA must ensure the U.S. does not lose unique process and production capabilities due to a lack of work.

Impact of Management and Labor Practices

Requirements and budget constraints do not support the present munitions industrial capability. Those corporations who wish to survive and continue to support defense munitions requirements have taken such measures as restructuring their organizations into leaner, more responsive product teams, focusing on broader global markets, or consolidating/merging with former competitors or associated firms. Additionally, some corporations have diversified in order to take advantage of dual use technology and its application in the commercial market.

As a result of the drawdown in the munitions industry, many companies have had to lay off many of their highly skilled workers, particularly scientists and engineers. Because these workers have largely migrated to other business sectors, the art associated with their skills is lost.

Trends

Technology. Modern weapons have increased in complexity over their predecessors. Today's munitions require a wide variety of disciplines and technologies to provide the destructive part of the combat capabilities of U.S. armed forces. These disciplines and technologies include many technical specialties: explosives, propellants, metal machining, warheads, electronics, fuses, software, guidance systems, optics, manufacturing processes, composites, and low observable technology.

Research & Development (R&D) and Capital Expenditures. Much of the munitions industry R&D is conducted in conjunction with the development of specific munitions, or within the auspices of the government's own laboratories run by DoD and DOE. DoD direct funding for munitions R&D has declined in recent years, but not nearly as sharply as procurement funding. DoD capital expenditures are currently negligible. The decline in demand and the uncertainty about future demand has discouraged private sector capital investment and R&D expenditures. In addition, munitions manufacturers can no longer count on recouping their R&D investment, capital expenditures, and development losses in large, long production runs, further discouraging independent R&D and capital expenditures.

PERFORMANCE

Sales Trends

Defense budgets have been declining from a peak of about $390 billion in 1985 to about $254 billion in 1994 (in constant FY 1995 dollars, a 35% reduction). The Procurement and RDT&E budgets have declined from about $176 billion in 1985 to about $81 billion in 1994 (more than 50%), and, under current plans, will decline further to about $80 billion in 1999. Defense procurement has decreased 66% in real terms since 1985.

The ammunition budget reflects these overall defense trends, decreasing from $5.6 billion in 1985 to $2.2 billion in 1992, with continuing decreases to $1.4 billion in 1994. This 1994 ammunition budget was the smallest in 20 years. A modest increase was appropriated for 1995, with procurement appropriations for Navy/Marine and Air Force ammunition separately cited. However, decreased funding is projected for 1996 and 1997. In 1992, peacetime procurement for propelling charges was $152 million; by 1994, this funding had been zeroed. Other significant ammunition reductions from 1992 to 1994 included artillery ammunition (97% reduction), bombs and dispenser ammunition (98%), mortars (83%), FASCAM and other mines (81%), and small caliber ammunition (59%).

The trend in the military services with respect to munitions is to procure highly sophisticated, accurate, "smart" munitions whenever possible. This trend has put further pressure on the producers of conventional ammunition as most of the munitions procurement budget has become focused toward purchasing missiles and PGMs. In FY 1994, there were 11 types of missiles in production. That number is expected to remain unchanged in FY 1995. In most cases, production quantities for missiles are expected to decrease due to a decline in current requirements..

The picture appears rosier for the production of PGMs. For example, WAM and SKEET production quantities are expected to rise steadily through FY 1999. If technical problems are overcome with BAT, that PGM is expected to also experience increasing production quantities through FY 1999.

The trend of the future may be to procure "competent" munitions which will be capable of "sufficient" effectiveness at low cost, and "insensitive" munitions which will be resistant to accidental or attack-induced stress events, such as heat, shock, or impact, causing detonation.

Profitability

Title 10 of the U.S. Code requires DoD to complete a series of industrial base assessments and produce a comprehensive industrial base plan each year. Within DoD is a newly established Assistant Secretary of Defense for Economic Security, and a Defense Industrial Base Oversight Council, established in April 1994 and chaired by the Deputy Secretary of Defense. These positions are to provide guidance for and oversight of an Industrial Base Review of DoD policies and programs affecting industry. Action Groups are to conduct reviews in six areas including Essential Defense Capabilities, Dual-Use Technology, Acquisition Reform, Public/Private Infrastructure, Base Closing and Realignment, and International Issues & Foreign Military Sales. The first document provided to Congress under the new Title 10 requirement was the Industrial Capabilities for Defense, September 1994. This document addressed only two industries, one being "Conventional Ammunition Industrial Assessment: Phase I." This review did not consider the missile and PGM segment of the industry. The assessment

reviewed 57 of the 102 companies involved in conventional ammunition production in 1992, and found 12 to be unprofitable then. The review identified 16 companies for further detailed evaluation. Findings were that the production capacities of 12 of these 16 producers could be absorbed by the remaining producers. The capacity of the other four producers likely could not be readily absorbed by the industry. Three of these four companies are single source producers. A "Conventional Ammunition Industrial Assessment, Phase II," is in progress.

International Trade and Competition

The U.S. is the world's preeminent exporter of armaments, with at least a 60-65% share of world exports. The U.S. government controls armaments exports by requiring companies to obtain an armaments export license from the Department of State for the sale of any armaments abroad. This restriction supports U.S. policies of limiting arms proliferation and technology transfer.

While U.S. munitions industry consolidation has become commonplace, not surprisingly, the European munitions industrial base has been downsizing over the past 7 years, as well. During this period, U.S. munitions makers have continued significant international sales. This success has been based primarily on their systems' demonstrated successes in the Gulf War. However, in the past 3 years, European industry has responded to this success by developing equally capable PGMs, which it is now successfully marketing internationally. Any lack of self-restraint by the U.S. and its allies in exporting technology and these weapons abroad raises concerns:

• U.S. companies relying heavily on foreign sales to replace their decreasing domestic sales.
• U.S. and allied warfighters may be threatened with such capable systems in future conflicts.

Moreover, out of budgetary necessity, European nations have co-developed many weapons systems. As the U.S. defense budget decreases, the U.S. may have to follow suit and enter into international cooperative programs. The current Medium Extended Air Defense System (MEADS), now envisioned as a cooperative U.S./European program, is a critical demonstration of U.S. resolve and commitment to cooperative development programs.

European governments employ different approaches to arming their forces. The UK industrial base philosophy is rather laissez faire, fostering global competition to satisfy British military requirements. The British believe this policy challenges UK industry in the short term, but increases their industry's competitiveness in the long term. However, more than 90% of UK Ministry of Defense (MOD) contracts are still won by British firms. The British describe their program management style as "hands off, eyes on". The Germans are a little more focused on maintaining national industrial capabilities.

They feel certain industrial sectors are vital and will do what is necessary to keep them alive. The German MOD position is to buy German, than Western European Union and European Union before looking across the Atlantic for suppliers. The French have a similar approach to that of the Germans. They take this policy one step further with government-owned companies like Aerospatiale. Despite differences, European allies seem unanimous in their view that the U.S. had not been a reliable development partner in the past.

OUTLOOK

Conventional Ammunition Short Term Outlook (1995-2000)

The defense build-up during the Cold War years created large amounts of excess capacity based upon then-current requirements. By the end of 1995, the government-owned portion of the ammunition base is expected to have fewer than 10,000 employees, compared to 26,000 in 1988. Every effort is being made to determine accurate requirements for the sustainment and readiness of ammunition training, war reserve, and industrial capability. OSD is working on reforming this requirements process.

The Ammunition Facility Strategy for the 21st Century (AMMO-FAST-21) is being used as the vision for maintaining a viable ammunition industrial base in the future. According to Industrial Operations Command, this strategy applies to the entire production base (commercial and government-owned facilities). In general terms, the strategy outlines where production for DoD requirements is to be performed and identifies what government property is no longer needed to support the SMCA mission. The strategy is designed to protect critical core capabilities, technologies, and skills (versus specific firms or facilities) associated with this primarily defense unique sector. Also, in an effort to conserve precious dollars, facilities and infrastructures operating at less than capacity, or idle, are being offered to commercial activities under contract or leasing agreements.

According to AMC, war reserve stockage requirements are expected to decrease by 69% from 2,500,000 short tons to only 775,000 short tons. This remainder is considered sufficient to support a 10 division active component force under the two MRC concept. Additionally, the industrial base is shrinking rapidly in light of future budgetary requirements. The number of ammunition plants will have decreased from a 1978 figure of over 300 to less than 70 in 1995. Government-owned (GOCO/GOGO) ammunition plants at the end of this year will only number 26 (8 active, designed as centers of excellence with unique capabilities; 14 inactive; 1 depot; and 3 excess).

Conventional Ammunition Long Term Outlook (2000 to 2010)

The Army's Ammunition Stockpile Management Plan for the future consists of a depot tiering concept:

• Tier I: Active Core Depot/Installations designed to support full-up activity levels with stocks for training and war reserves to meet the first 30 days of contingency requirements.
• Tier II: Cadre Depot/Installations used for static storage of follow-on war reserves beyond the first 30 day contingency requirement.
• Tier III: Caretaker Depots/Installations minimally staffed and containing non-required stocks until disposition can be made.

A future growth industry is in the area of ammunition demilitarization. According to Industrial Operations Command, the current SMCA stockpile of excess and obsolete munitions is over 400,000 short tons stored throughout 15 locations in the CONUS. This demilitarization workload will aid in the maintaining of both government and commercial facilities, munitions expertise, and the ability to respond during mobilization.

While obsolete ammunition is destroyed, ammunition of the future will increase in technological sophistication and capability like its missile and PGM munitions counterparts. Such technological improvements may include more sophisticated fuses and liquid propellants.

Precision Guided Munitions Short Term Outlook (1995-2000)

The development and acquisition of PGMs is key to U.S. defense strategy. U.S. and allied strategic assumptions place a great deal of emphasis on the emergence of a new generation of PGMs before the end of the century to offset declining force levels. However, concerns are emerging that near-term weapons needs are being ignored at the expense of these new "smart" munitions, which may not materialize as fast as expected or be as cheap, accurate, and resistant to countermeasures as advertised. These cost, schedule, and performance issues are DoD's and industry's challenges for today and the future.

Precision Guided Munitions Long Term Outlook (2000 to 2010)

DoD would like to completely abandon the use of "dumb" bombs and invest in programs that upgrade these types of munitions. Increased accuracy and effectiveness of PGMs can decrease overall costs and prove to be both a force and weapon system multiplier. Examples of PGM programs scheduled for fielding around the turn of the century are:

• Joint Stand-Off Weapon (JSOW): Joint U.S. Navy/Air Force venture with Texas Instruments to produce a 1,000 pound, winged weapon with INS/GPS guidance. The system will carry a variety of munitions and is expected to be fielded in 2001.
• Line Of Site Antitank Weapon (LOSAT): Army system that will fire line of site kinetic energy missiles against hard targets such as armored personnel carriers and tanks. The system is presently in technology demonstration phase of development.

• Affordable Stand-off Missile (ASOM): U.S. Air Force follow on to the recently canceled TSSAM. This procurement is expected to be an accelerated program that takes advantage of TSSAM technology and provides a standoff capability. The British also have a strong interest in this system and a joint venture would certainly decrease the overall cost of the system. The acquisition process is expected to reach Milestone 0 by the summer of 1995.

These are only a small number of PGM programs designed for production and fielding around the turn of the century. Additionally, future technological advances in the PGM arena may be discontinued after development of prototypes and placed "on the shelf" for future follow-on development or production. This concept allows technological advances to continue while saving critical production cost dollars. However, such postponement of production operations also makes it more difficult to surge production capability when required.

WMD Outlook

WMD issues are very complex and not easily solved. The U.S. current WMD capability exceeds its requirements, driving most of the WMD associated problems:

• Treaty provisions call for destruction of a large part of the U.S. inventory. This destruction involves a massive demilitarization and cleanup effort. For example, the estimated cost for demilitarization of chemical weapons alone is more than $12 billion. This huge bill is coming directly from the procurement accounts. Thus, the amount of money available to meet other DoD requirements will be adversely impacted.
• Nuclear weapons have a limited shelf-life. As these weapons age, they will need some level of continuing maintenance to keep them safe and operational. The U.S. will need to have some continuing capability to remanufacture or repair components, produce consumables, design and implement necessary safety changes, and finally to test the results.
• U.S. inability to test nuclear weapons is currently causing concern about the future safety and viability of these weapons. The U.S. can currently simulate the weapons delivery and firing but cannot do true end-to-end testing.
• The nuclear weapons industrial base represents a unique challenge. The U.S. is attempting to maintain a credible nuclear capability while drawing down an aging inventory with a limited shelf-life. This is rapidly becoming a very demanding task because of no testing, relatively insignificant R&D, and no currently planned production. The critical skills base required to maintain U.S. nuclear weapons base is rapidly evaporating, further highlighting the need to maintain a viable working infrastructure. Nuclear weapons engineers are not "grown" in colleges or universities, but require many years of apprenticeship working with seasoned scientists to become competent nuclear weapons developers.

INDUSTRY STRATEGIES FOR SURVIVAL

Why worry about the munitions industrial base? Defense manufacturing has been a strong element of industrial power for the U.S. It has provided a strong military tool of national power, but a poorly implemented downsizing could unintentionally amputate critical portions of U.S. military strength. Military planners and policymakers must be cognizant of the downsizing processes defense companies are using to survive. These planners need to be assured that civilian sector resources remain available to support a given military strategy, particularly for reconstitution of military supplies.

Problems Facing the Industry

Munitions firms face a doubled-edged sword. Decreasing market share is the forward edge of this sword. Markets are declining for two reasons: lower procurement and a changing military strategy. Military procurement accounts have decreased 50% between 1985 and 1994. For the ammunition accounts only, the budget has decreased from $5.6 billion in FY 1985 to $1.4 billion in FY 1994. This reduction has had an obvious effect on ammunition suppliers. Dealing with decreased market size due to lower purchasing volume is just one problem facing the munitions industry in establishing a business strategy.

If these firms survive the forward sweep of the downsizing sword, they must still dodge the sword's returning edge: a changing post Cold War strategy that moves away from maintaining a large scale defense industrial base geared to supporting global conflict levels. As a result of the Bottom Up Review (BUR), military strategy led to a shift in mobilization policy that placed less emphasis on maintaining a vast defense industry mobilization base and moved towards a "come as you are" war philosophy with dependence on using existing stocks of ammunition without ramping up ammunition manufacturing. Having abandoned its long-standing policy of maintaining a "warm" ammunition base capable of replenishing stocks as they are consumed, the U.S. now plans to draw all ammunition needed for future conflicts from existing stockpiles and to replenish ammunition stores after conflict termination. This smaller base strategy works with lower annual purchases to reduce the need for manufacturing capability even more, adding to the problems of lower purchases. This shift in market makeup complicates the industry's job in mapping a future: short term and long term pressure on operating income, sudden manufacturing over-capacity, and loss of long term vision on the future industry makeup.

Many think ammunition is a critical defense area that needs special exemption from the post Cold War strategy. In 1992, a FEMA-sponsored modelling effort by the Institute for Defense Analysis rated ammunition suppliers at the bottom of 35 critical sectors of the U.S. industrial base in their ability to replace material needed for a conflict. In 1992, an Army Materiel Command study rated the ammunition sector the weakest of 13 defense industrial sectors. In 1994, another FEMA study reflected little improve-

ment in the ammunition sector. According to one study, in 1991, the services could rely on a production base capable of responding to large-caliber ammunition requisitions in less than 6 months. Today, an order for artillery ammunition would take up to a year to fill; some mortar and tank rounds take more than a year. Defense planners continue to hold on to the notion that military mobilization for war means responding to threats with high levels of responsive manufacturing conversion to support a war effort in a timely fashion using only domestic suppliers for the most part. Before World War I, the U.S. depended primarily on foreign and domestic commercial suppliers to meet its small ammunition requirements. Once the U.S. entered the war, these sources proved inadequate, forcing the government to build 32 plants to augment commercial suppliers. As the war ended, lead time for small arms was 12 months and 18 months for artillery. Balancing past history, current strategy, and the chance for future special consideration, munitions producers are left in the Twilight Zone of industrial strategy, unsure whether they should bet on being "special" and go for maintaining a warm manufacturing base, or move to streamline with shifts of capital towards a commercial market sector.

Effects of Shifting Market on Industries Strategies

Over-capacity, decreased operating income, and increased instability are the prime factors that must be addressed in munitions company's survival strategy. This situation means industry strategists must focus on downsizing in their strategic plans. Downsizing creates two complicating issues: keeping a trained workforce for future work and handling the environmental costs of closing excess production facilities. Shifting munitions market makeup is resulting in over capacity, decreased operating income, and increased instability. Each of these effects are interrelated and work coactively to complicate the industry strategist's task.

Effect of Overcapacity. Understandably, vast overcapacity in the industry is one result of changing market characteristics. Running the day to day business at a profit becomes the most basic concern arising from reduced purchases. Industry strategists must focus on downsizing in their strategic plans. This leads to at least two complicating results for future planning: keeping a trained workforce for future work and handling the costs of closing excess production facilities.

Keeping a Trained Workforce. Without the need for vast mobilization capacity, the government is less likely to support warm lines for mobilization use. The need for these lines for reconstitution strategies is hard to pin down. This means that trained teams and lines for ammunition will decrease. Workers will be the first to disappear. However, if the industry planner wants to compete in the future, he will need to keep a trained core workforce available. This will not be easy without supporting contracts and work to pay for them. Companies that attempt to remain in the business will need to adapt strategies for adjusting workforces adeptly by such techniques as leasing workers from other companies; swapping workers or work within divisions; cross train-

ing workers to develop core, broad-based experts to lead larger teams when there is work; or other alternatives. In short, the company planner must be creative in making sure a trained workforce is available for profitable business tomorrow without breaking the company today.

Costs of downsizing: Modernization & Environmental Costs. Most strategies for improving competitiveness would be to modernize. The ammunition area is not very conducive to modernization construction techniques given reduced demand. This leaves closing plants as the alternative. Unfortunately, the biggest cost of downsizing to the munitions planner would be environmental costs of cleanup for closed facilities. This is particularly sensitive for ammunition work as most plants have been in business long before environmental concerns became a reality and have been involved in weapon production processes that are particularly environmentally complicated. Industry planners are potentially hamstrung by conflicting limitations on increasing efficiencies: hard to streamline the manufacturing process and hard to downsize by closing plants due to environmental costs.

Effects of Decreased Operating Income. The specter of decreased operating income has two major downsides: with reduced income, capital becomes harder to obtain; and without capital, R&D funds become scarce at time when investing in R&D to effect changing survival strategies. Lower operating income leads to decreased availability of capital by increased interest for borrowing. Additionally, the U.S. has plenty of ammunition. DoD is developing improved munitions in the labs, but not producing them due to having plenty stockpiled already. Thus, there is less government investment in new weapons production and companies no longer have this government contract money to leverage R&D expenses.

Effects of Increased Instability. As already examined, the fluid state of industrial base policy has led to uncertainties about the future market makeup. This leads to higher risk, which leads to higher interest rates, which leads to higher capital costs, which leads to a declining capability spiral. Instability serves to intensify the effects of the declining market. The company strategist must decide where to jump off this spiral of decline and commit to a plan: an unenviable leap.

Possible Munitions Industry Strategies

There are some general strategies that a company planner could consider. They have, not surprisingly, some advantages and disadvantages. Other than closing up shop and getting out of the munitions business altogether, possible strategies include: right-sizing, specialization, diversification, and expansion.

Right-sizing. Using this strategy, companies address the overcapacity in the ammunition and PGM market through plant closings and consolidations to decrease fixed costs. This appears to the most successful strategy so far. The ammunition and PGM

related companies examined all had right-sizing in their strategic vision. This trend will likely continue.

Specialization. In this strategy, a company decides to focus on its strengths and cut off those areas where it believes it's a marginal competitor. This decision is based on determining which areas of munitions manufacturing the company has a marked comparative advantage and choosing to compete in those areas. This strategy recognizes that lower operating income and R&D costs are not available for creating comparative advantages in new areas. Therefore, the company seeks to become a survivor in the short term and a competitor in specialized areas in the long term. The hard part in developing this strategy is in deciding where the company is superior, and getting rid of the other parts of the company. There is also no guarantee that the core competencies chosen to develop will be ones that survive in the long run.

Diversification. Some companies may look to diversification in other areas as a way to increase total operating income while waiting for the munitions market to improve. Moving munitions technologies to the civilian sector can provide success in this approach. This has been done in some cases. The problems with this approach are that companies still need R&D capital and there is still no promise that the civilian ventures can replace income lost from basic company strengths. These ventures may also serve to dilute companies' ability to compete in the defense sector.

Expansion. A fourth survival strategy is expansion by either merging or increasing sales, particularly overseas. This approach favors the larger company or at least the ones with long term existing defense work still in progress. The major limitation on mergers is government regulation. For example, a proposed merger of two munitions firms was halted over concern that this would result in only one source for critical tank ammunition. Attempting to increase exports is a second method a company might seek to expand. This is not a stable strategy. U.S. technology transfer policy doesn't facilitate this approach, generally hindering high technology exports.

Recommendations for Industry

Commercial Practices. Munitions manufacturers must continue their efforts to reduce costs by identifying and implementing commercial "best practices" whenever appropriate. Contractors in the munitions industry should jointly develop commercial standards in process areas where guidelines other than government specifications do not exist.

"Best Value". Defense contractors must understand that the government's transition from "low bid" to "best value" contracting is real and something they need to understand and support.

Foreign Sales Reassessment. Many U.S. munitions firms are counting heavily on

foreign sales to make up for reduced U.S. procurement quantities. As other countries develop and sell comparable weapons, the competition for this lucrative market will increase. This fact is highlighted by the plans of Western European Union governments and defense industries.

Partnership. As the munitions industrial base continues to shrink, partnering with both domestic and foreign companies will be required to compete in the new global market place. U.S. industry should quicken the pace to find compatible overseas teammates.

GOVERNMENT RESPONSE AND ENABLING POLICIES

The following are recommendations for government action:

- Establish a logical system or terminology framework for characterizing, categorizing, and identifying ammunition. The current nomenclature is mired in an antiquated cataloging system that simply assigns sequential numbers to new munitions. Historically, munitions management has been a major problem area. The world has changed, and the U.S. can expect to be engaged in coalition warfare in the future, requiring international logistics as a way of life. Rationalization, Standardization, and Interoperability (RSI) will assume increasing importance for future conflicts. U.S. munitions stockpiles can be expected to be smaller in the future. It will be crucial, in assessing the viability of the munitions industrial base, to know what are U.S. requirements for various types of munitions, what quantities and mixes of preferred and suitable munitions are adequate to U.S. forces' needs, and what does the U.S. actually have in the stockpile and where. A structured framework for identifying munitions also needs to be adopted by U.S. allies, to improve the management of international logistics and RSI.
- Institute use of commercial acquisition practices. Methods and processes developed and used in the private sector under competition tend to be cost effective and materially efficient while yielding quality products. Traditionally, in a valid attempt to control cost and quality, the government has constrained defense industry in the methods and processes used to develop and produce weapons and military equipment. As the defense industry has contracted, the volume of work is forcing unique defense manufacturing firms to broaden into the commercial sector. Relaxing the constraints on industry allows the use of proven commercial practices. Commercial acquisition practices will provide weapons and supplies faster and cheaper than with defense-unique methods.
- Conduct a comprehensive precision munitions study. The DoD ammunition study accurately described the status of the ammunition part of the munitions picture. This effort must be expanded to include the preferred munitions of the 21st century--precision guided munitions.
- Increase procurement of preferred munitions. Although the U.S. munitions inventory is large in terms of pounds of bombs, rounds of artillery shells, and numbers of bullets, the U.S. preferred munitions stockpile remains low. The government must make the

commitment to financially support the future buys of preferred munitions.

• Select PGMs over platforms. In this period of greatly reduced investment accounts, the DoD must modernize U.S. forces with more affordable PGMs in lieu of costly new delivery platforms. DoD should delay acquisition of new platforms until such platforms can reflect a leap in technological advantage. Recent decisions by USAF and OSD to procure smart weapons rather than buy additional B-2s is an encouraging example of this approach.

• Fund multi-year procurements at optimal levels. Part of a wise resource utilization approach should include the use of multi-year contracts to get more "bang for the buck" and provide stability for munitions acquisition programs.

• Incentivize industrial R&D. The division of R&D funding between the government's laboratories and private industry should be examined and perhaps adjusted. With the drawdown in the DoD procurement budget, the funding for research available to private industry in the form of independent research and development (IR&D) has been significantly reduced.

• Improve the requirements determination process. It is a cumbersome, disjointed effort that often results in redundant, unfocused development projects and unsubstantiated inventory objectives. The joint warfighters echo this perspective.

CONCLUSION

A study sponsored by the Munitions Industrial Base Task Force concluded that, "Meeting the requirements of two nearly simultaneous contingencies would generate a munitions demand exceeding the capacity of the industrial base by more than 60 percent." This conclusion may be parochial, but certainly should raise concern that the munitions industrial base may be in jeopardy of becoming too small to meet military requirements. There are certain critical munitions capabilities that need to be maintained for our future national security. It will take intensive management to ensure the reduced base survives with all its required capabilities intact. While the U.S. definitely still has the lead in technology, U.S. ability to rapidly produce high technology weapons on a large scale has diminished substantially. As a direct result of the success enjoyed by American arms during DESERT STORM, U.S. weapons manufacturers have become the armorers to the world. This position is apt to be short lived as other nations take advantage of these technologies and build on them. Inherent in this proliferation of high technology weaponry is the very real possibility that American forces will have to face weapons as good or better than their own. This concern alone is clearly an incentive to boost the R&D efforts in the munitions field. Key policy makers have stressed the importance of high technology and smart weapon systems for U.S. national security. Precision guided munitions are a means to rapidly exploit the information technology revolution, and are representative of the direction the revolution in military affairs will take U.S. forces. The U.S. must continue to look forward in meeting its warfighting needs, or risk falling behind.

INDUSTRY STUDY

#15

SHIPBUILDING

TABLE OF CONTENTS

PARTICIPANTS

Students

CAPT Thomas J. Brown, USN

Mr. Stephen Coakley, GM-15, D/A

COL Charles W. Fletcher, Jr., USA

Mr. Clifford Hall, GM-15, D/AF

LTC Susan S. Halter, USA

LTC Peter C. Losi, USAF

CDR Christopher M. Moe, USN

CAPT Richard K. Perkins, USN

CAPT Sergey Sevastyanov, Russian Navy

CDR Timothy S. Traaen, USN

RADM Jose Valdes, Mexican Navy

Faculty

Dr. Irene Kyriakopoulos, GS-15

CAPT John Kuchinski, USNR

COL Thomas Mulrine, USA

CAPT Scott D. Parry, USN

PLACES VISITED

Domestic

Carderock Division, Naval Surface Warfare Center, David Taylor Research Center	Carderock, MD
Newport News Shipyard	Newport News, VA
Bollinger Machine Shop & Shipyard, Inc.	Lockport, LA
Halter Marine Shipyard	New Orleans, LA
Avondale Shipyards	New Orleans, LA
Textron Marine & Land Systems	New Orleans, LA
Inqalls Shipyard	Pascagoula, MS

International Travel

U.S. Embassy	Helsinki, Finland
Finnish Ministry of Defence	Helsinki, Finland
Kvaerner Masa-Yards	Helsinki, Finland
Kvaerner Masa-Yards Arctic Research Center	Helsinki, Finland
State Technology Center (VTT)	Helsinki, Finland
Finnyards	Rauma, Finland
Kvaerner Masa-Yards	Turku, Finland
U.S. Embassy	Stockholm, Sweden
Swedish Defence Material Administration (FMV) Naval Material Command	Stockholm, Sweden
Kockums AB, Submarine Systems	Malmo, Sweden
Bruce's Shipyard	Landskrona, Sweden
Oresundsvarvet Shipyard	Landskrona, Sweden
U.S. Embassy	Copenhagen, Denmark
Danish Ministry for Industry and Coordination	Copenhagen, Denmark
Association of Danish Shipbuilders	Copenhagen, Denmark
Danish Shipowners' Association	Copenhagen, Denmark
Danyard Shipyard	Aalborg, Denmark
Odense Steel Shipyard	Odense, Denmark

GUEST SPEAKERS

Mr. Ande Abbott	Director, Shipbuilding and Marine Division, Boilermakers Union
Mr. Frederick Beer	Assistant for Acquisition, Navy International Programs Office
Mr. Jim Brennan	Acting Chief, Land & Sea Team, Industrial Analysis Support Office, Defense Logistics Agency
Mr. William Crowder	Consultant, Logistics Management Institute
Mr. Charles Dragonette	Senior Analyst, Civil Maritime Analysis Dept., Office of Naval Intelligence
Mr. H. C. Fortenberry	Research Fellow, Operational Logistics, Logistics Management Institute
Richard Gupman, CAPT, USCG	Program Manager, Naval Sea Systems Command
John Horton, CAPT, USN	Navy International Programs Office
Dave Householder, CDR, USN	Navy International Programs Office
Mr. Ronald Kiss	Deputy Assistant Secretary of the Navy (R,D, & A)
Mr. John Lewis	Office of Naval Intelligence
Mr. Michael McClatchey	Office of Naval Intelligence
Dr. David Morrissy	Director, Capital Goods Trade Policy Office of U.S. Trade Representative
Mr. Silas Nunn	Acting President, Shipbuilders Council of America
Mr. Raymond Schaible	Research Fellow, Operational Logistics, Logistics Management Institute
Dr. Bob Scheina	ICAF Faculty

INTRODUCTION

A ***significantly reduced naval shipbuilding*** program is critically stressing all first-tier and some second-tier American shipyards as they consider the prospects for the next decade. U.S. shipbuilders have generally depended on naval construction and repair for sustained production and growth for more than a decade; they have produced high quality warships that are among the most complex ships in the world. However, without the naval building program, first- and second-tier yards must dramatically down scale their work force toward the minimum necessary to keep production lines open. Some yards fail. Others are absorbed by larger yards. The type, location, and ***capability of the yards that survive this restructuring of the industry over the next five years will determine future strategic capability*** to build combatant, amphibious, or strategic lift ships.

Warm production lines for warships and strategic sea lift are essential in a time of mobilization in order to face an aggressive emergent or re-emergent naval power or a well capitalized rogue state. The ***shipbuilding sector of the Defense Technology Industrial Base (DTIB) is a fundamental component of US power projection.***

Several ***global trends affected*** the U.S. shipbuilding industry in recent decades:

--A depressed shipbuilding market due to excess supply conditions in late 1970s combined with a declining oil trade.
--The Reagan Administration termination of construction differential subsidies.
--Cold War surge in naval construction masked depression in the market.
--Worldwide down scaling of defense procurement after end of the Cold War.

However, today U.S. firms have ***an opportunity to reenter the commercial market and become world class competitors***--if they chose the right niche markets to enter and if they chose the right domestic and international partners in strategic alliances.

The National Shipbuilding and Shipyard Conversion Act of 1993 reflects serious concern for viability of this capital-intensive, expertise-intensive defense infrastructure. The President's ***Strengthening America's Shipyards: A Plan for Competing in the International Market*** responds, in part, to that concern and seeks to reestablish the U.S. shipbuilding industry as a self-sufficient, internationally competitive industry--building commercial ships for export. Worldwide competition must be investigated and then monitored continuously if public policy is to successfully (directly or indirectly) encourage ***conversion to commercial activity on a competitive basis.*** Consequently, this Industrial College of the Armed Forces (ICAF) Shipbuilding Industry Study initially focused on surveying U.S. shipyards, both large

and small, to gauge their reactions to and their prospects under the ***Conversion Act*** and the President's Plan. An early realization was that there were very different attitudes within the industry in the areas of:.

--the need to export vessels
--our ability to export commercial vessels
--the need for government assistance

Not only did these differences fall along first-tier and second-tier shipyard lines, but they fell into distinct areas of specialization within the shipbuilding industry--sometimes within the same shipyard. It appeared there might be ***subordinate shipbuilding industries that might actually manifest different structure and conduct and, as a consequence, might have different measures of performance*** The formulation of public policy to support the shipbuilding industry would be even more complex if these postulations were true. It might also suggest that there are more opportunities for American firms to seize niche markets for export than is generally envisioned in the President's Plan.

The study group examined both domestic and international shipbuilding activities. A matrix reflecting characteristics examined in four areas (naval surface, naval submarine, commercial ship, and R&D) is offered in *Chart 1.* The research validated the concept of distinct industry subsets which behave or are structured differently, and which should warrant differing levels of concern by the government both in terms of competing commercially and in terms of viability in the future DTIB. It is hoped that subsequent industry study efforts will attempt to address the less well developed areas of our effort in order to flesh out the entire matrix for the ICAF.

There have been several ***noteworthy events since last year:***

-- The Organization for Economic Cooperation and Development (OECD) and South Korea signed the OECD Shipbuilding Agreement

-- The Shipbuilder's Council of America (SCA) fragmented over the OECD Agreement and five major shipyards formed the American Shipbuilders of America (ASA)

--A first-tier shipyard has two orders for tankers for a Greek owner supported by a Title XI loan guarantee.

-- Another first-tier shipyard has teamed with a German firm to build diesel submarines for export from the US..

-- Another German shipyard has offered to manage a closing U.S. Navy yard to convert it to building cruise ships, thereby preserving one half of the public yard's work

force.

In our analysis of these events, our research, and our field studies we found that ***there were trends*** evident that ***offer specific opportunities for reinvigorating selected parts of the U.S. shipbuilding industry and for maintaining specific segments of the naval construction sector of the DTIB.***

STRUCTURE

Building Blocks

American and international shipbuilding both include building and repairing ships of various sizes and complexity--both military and commercial. The continuum includes huge industrial complexes belonging to large conglomerate participants located in major ports with cranes capable of lifting hundreds of tons down to small family-owned businesses in remote locations building ships "by hand."

The American shipbuilding industry consists of public (government), private (commercial) shipyards, and key sub-tier manufacturers engaged in the design, manufacture, and/or maintenance of naval and commercial vessels and key shipboard systems. There is an important distinction between those elements of the industrial infrastructure that possess conventional capabilities and those that possess nuclear capabilities. *Chart 2* outlines the key elements of the shipbuilding industrial base.

There are about 700 U.S. shipyards or repair activities of varying sizes and capabilities. There has been a dramatic reduction in the number of U.S. shipyards over the last 12 years. Most importantly, the number of shipyard facilities necessary for the assembly of a ship over 400 feet in length has declined over 40 percent. A traditional benchmark for tracking the U.S. shipbuilding industry is the Active Shipbuilding Base (ASB) as defined by shipyard capability and certain business criteria. Because of the reduction in new construction, ASB was replaced by a new criteria which consists primarily of shipyard capability. The new benchmark is the U.S. Major Shipbuilding Base (MSB), defined as privately owned shipyards that are open and have at least one shipbuilding position, either an inclined way, a side-launching platform, or a building basin capable of accommodating a vessel 122 meters in length or over. Nineteen major shipbuilding facilities comprised the MSB as of October 1993 and are expected to decline towards 11 by 2000. *Chart 3* depicts the six yards with most of the Navy contracts.

First-Tier Shipyards

The first-tier yards which appear to be the most resilient are the three major conglomerate participants in U.S. shipbuilding: Electric Boat Division (General Dynamics), Ingalls (Litton), and Newport News (Tenneco). The relative importance of

the marine engineering divisions of the conglomerates are less than one quarter of sales, yet the volume of sales is quite substantial. These three are listed with other first-tier yards in *Table 1* illustrating firms holding major Navy contracts over time.

Second-Tier Shipyards

This segment includes some of the smaller yards with Navy contracts. They generally construct and repair smaller vessels such as inland waterways and coastal carriers, tug boats, supply boats, ferries, fishing vessels, barges, drill rigs, and small military and government-owned vessels. Some of these yards are competing successfully in specific international markets. However, most build ships for the domestic market which is protected by the Jones Act. That Act restricts U.S. coastwise and inland maritime traffic to U.S.-built ships sailing under the U.S. flag. These yards are most often non-union operations. They do not face the same conversion problems as those yards in the MSB. We found Trinity Marine Group to be an innovative representative of this industry sector.

Third-Tier Suppliers

There are hundreds of private sector and government-owned industrial facilities in place today that design, develop, produce, and maintain subsystems and components required to support the shipbuilding industry. The shipbuilding sub-tier industrial base is sub-divided, for convenience, into three categories: *Nuclear Systems, Combat Systems, and Ship Systems.* In general, Combat Systems manufacturers are dependent upon defense programs while Ship Systems manufacturers are more diversified and less specialized in marine product lines. Nuclear Systems vendors are solely dependent on Navy business and must be closely monitored to assure their capabilities are sustained.

Nuclear Shipbuilding

Over the last 20 years, the number of shipyards engaged in construction of nuclear-powered ships and submarines has decreased from seven to two: General Dynamics Electric Boat Division (EB) and Newport News Shipbuilding and Drydock Company (NNS). These yards are of particular concern because of their specialized, unique integration and production capabilities.

Labor

According to the U.S. Department of Labor, aggregate employment in commercial shipbuilding and repair was 109,000 in 1993, down from 123,000 the year before.[1] The MSB shipyards employ about 73 percent of the total work force of the industry (90 percent of the MSB labor force is unionized). The remaining 27 percent is spread over some 550 establishments with 10 or more employees. The majority of

these are non-union employees.

The shipbuilding industry will decline as the industry reduces the Navy backlog created during the build-up period of the 1980s. Employment levels could decline by as much as 40 percent by the year 2000 if commercial work cannot be obtained to off-set reductions in Navy work. Employment levels required to support potential Navy shipbuilding programs, including sealift, are expected to drop to a low of 45,000 employees by the year 1998 and then return to approximately 70,000 employees by the year 2007, based on current productivity levels and anticipated force-level requirements.

Customers

The U.S. shipbuilding industry received no new orders for ocean-going commercial ships in 1993, but received one order in 1994 with several more in the process of negotiation. The decline in the U.S. merchant vessel order book is clear: Navy programs continued to account for about 90 percent of the employment at those shipyards performing new Navy construction and repair work.

The Navy shipbuilding order book consisted of 86 hulls. The majority are being constructed by six shipyards. Navy shipbuilding funding has dropped from a high of $19 billion in fiscal year 1988 to just $4.3 in fiscal year 1994. Approximately 57 Navy ships (including sealift) are budgeted to be contracted in fiscal years 1994-99.

Barriers to Entry/Exit

The *shipbuilding* and *repair* industry has formidable barriers to both entry and exit. Construction yards require huge capital investments and demand large parcels of waterfront real estate for fabrication and assembly areas. A highly-skilled work force is also required. Access to the military market adds greater barriers. Navy work requires higher quality and greater engineering. It also involves more changes during construction and outfitting, and demands higher overhead to meet military contracting requirements than does commercial work.

Once lost, shipbuilding capability is difficult to resurrect. The SCA estimates that 6-7 years would be required to deliver a Navy combatant from a cold start. SCA concerns include the difficulty in obtaining property for new facilities, in attracting and training new workers, obtaining components and equipment.

The OECD Shipbuilders' Agreement (under negotiation at U.S. initiative since 1986) poses a barrier to entry to U.S. shipbuilding firms. However, without the agreement, foreign yards will continue to subsidize their yards, thereby perpetuating a competitive disadvantage to the U.S. producers. With the agreement, all subsidy schemes will be prohibited and thus, favorable supports such as Title XI loan

guarantees will not be available to U.S. builders.

The lack of market experience and resulting lack of commercial customer relationships is an ongoing barrier to market entry. U.S. shipbuilders' continued reliance on military shipbuilding has inhibited their development and exploitation of commercial customer relationships. They have not yet as a group (and in most, but not all, cases as individual firms) developed the skills necessary to identify market niches and provide for market needs.

The high cost of upgrading shipyards to facilities required for commercial competitiveness combined with the cash flow required for building commercial ships may be prohibitive for all but those yards which are part of a conglomerate. The fact these hurdles must be overcome in an environment of excessive capacity appears to be daunting as well. Global overcapacity and South Korea's intent to continue to increase capacity, serves as an additional deterrent to new entrants. This overcapacity and the willingness of some firms to take small profits or even losses in the short term to protect their market share will continue to make entry difficult, despite the projected increase in demand for vessel construction

Conclusions

--Market forces will drive the industry toward ***increased concentration and perhaps vertical integration.***

--Larger first-tier yards are robust enough to weather the restructuring and many of the ***second-tier yards are already producing for*** the ***commercial markets.***

--Most vulnerable are firms in the third-tier where the loss of a one-of-a-kind component or part producer could be very damaging to the DTIB.

CONDUCT

Naval Shipbuilding

Naval Shipbuilding is a monopsonistic relationship between the government and commercial shipyards in the United States. The government requires the construction of highly complex warships built to high quality. The excessive costs are due to two major factors:

--First and foremost is the number of change orders.
--Second is the lack of incentives to modernize.

The *first factor is* an outgrowth of an inefficient naval shipbuilding program that takes ten years to arrive at final design and hosts of change orders. The *second factor*

is an outgrowth of the Presidential and Congressional desires to keep employment high.

Foreign governments, particularly in Europe, are active members of the shipbuilding community as partial owners to varying degrees. Furthermore, the low numbers of complex ships and the emphasis on special and patrol crafts makes foreign naval shipbuilding different than in the United States.

Commercial Shipbuilding

Commercial shipbuilding is just restarting in the U.S. first-tier yards. Foreign shipbuilding by highly skilled and highly paid work forces like the U.S. first-tier yards is founded on three essential factors:

- Specialization in one portion of the market (cruise ships, very large cargo carriers (VLCC), ice breakers) as sellers of capacity rather than products.
- Long standing customer/builder relations
- Government support (subsidies, tax breaks, loans, guarantees)

Labor & Management Relations

Foreign yards have few problems with labor and management relations viewing the central issue as one of survival, especially in small countries. The alternatives for work are severely limited. The examples of "teaming" and "cooperative competition" are worth examining.

This is not the case for the U.S. in general, which enjoys a highly mobile work force. However, as force reductions continue as the industry shrinks due to over-capacity, the concern will be for retaining a minimum number of skilled laborers and managers who know how to build and assemble ships. Regions of the U.S. which are highly dependent on shipbuilding (like the Gulf Coast or Maine) will certainly suffer depressed economies as the industry restructures in much the same way as smaller countries with similar economic dependencies on shipbuilding.

Investments

Foreign yards have committed to long-term Research and Development (R&D) centered around two or three basic technologies like structure fracturing and sound isolation. This requires a relatively low level of funding for select numbers of highly skilled workers (BS, MS, and PhD levels). Additionally, funds are spent regularly in upgrading the process. Plant layout and robotics are leading investment areas.

U.S. yards are just starting to invest in the technology the foreign yards employ, but there is no clear overall strategy that binds such investments to selected

commercial markets.

Corporate Conduct

Foreign corporations are more closely tied to their customers, their bankers, and their governments than U.S. firms--largely due to U.S. concerns for behavior that might be interpreted as trust like activity. They have either a philosophy of remaining a leader in a niche market, like arctic ice breakers, or slowly diversifying into other businesses related to their basic technologies, such as trains, bridges, and computer software products--Computer Aided Management (CAM)/Computer information Management (CIM).

U.S. corporations have no commercial customer base, only a few American banks have a shipbuilding portfolio, and, while the relationship with the defense side of government has been good, the larger government policy of support has been weak in comparison to foreign counterparts.

Conclusions on Conduct

Along with the pressure to enter the commercial market and compete in an increasingly concentrated naval market comes ***the incentive to modernize--to stay alive.***

Yards trying to produce both types of vessels or to convert strictly to commercial work ***must develop clear strategies for specific market entry.*** **The fundamental *choice is between selling capacity for tailor-made ships and selling products with economies of series production.***

The Navy could help *reduce the MH/CGT and* the resultant construction costs by ***changing the process for change orders and ordering*** a few of the most viable ***export models of small frigates and diesel submarines.***

PERFORMANCE

Post-War Growth

The U.S. shipbuilding industry enjoyed a balanced mix of commercial and Navy work after World War II. Commercial deliveries averaged 20 ships per year from 1955-1985. Overall shipyard employment grew in the first three decades following the war. In 1980, their were 22 major shipyards employing 330,000 workers[2] *(see Chart 4).* Government funding for Construction-Differential Subsidies(CDS) for U.S.-Flag ships engaged in foreign commerce was a major factor in the commercial market.[3]

Unfortunately, these fast growing markets would soon face significant challenges, and ultimately the post-war balance (commercial-military) would die!

The Crash

What killed the U.S. commercial shipbuilding market in the last decade? During the 1980s the commercial shipbuilding market worldwide suffered from a massive market depression and a decline in oil prices. Governments responded with financial subsidies and in many regions shipbuilders reduced their profit margins in an attempt to stimulate orders. This practice, commonly referred to as "dumping" only aggravated the growing market depression. The newly formed U.S. administration noted that U.S. subsidies were running at 50 percent of the contract prices for commercial ships and in 1981, cancelled its CDS subsidy program.

As the commercial market in the U.S. continued to decline from 69 vessels under construction or on order in 1980 to no ships under construction or on order in 1990, U.S. shipbuilders were forced to look for new markets. Expansion of an already robust military shipbuilding program quickly overshadowed the significance of the decline in commercial ship construction, and it was not until the next decade that the decline in the U.S. commercial market was really felt. For the duration of this decade, six yards (Ingalls, Bath, Newport News, Electric Boat, Avondale, and NASCO) were sharing a military building program that exceeded 90 ships per year, and which was projected to *reach* 600 vessels. See *Chart 3.*

By 1991 the Cold War was over. Demands for a "peace dividend" made it politically unacceptable to maintain the current military build-up started under the Reagan Administration. Global War was reduced to Regional Conflict. The plan for a large Navy was dead! Ship de-commissioning as well as the transfer of many units to the reserves and military sealift would soon move the Bottom-Up Review (BUR) target of a 600-ship Navy to one of only 350 vessels. With orders in military construction dropping below 5 ships per year, it was likely that the current number of first-tier yards would decline to as few as 2, and employment would drop below 30,000 workers.[4]

The Comeback

Re-emergence into this highly competitive global arena of commercial shipbuilding began late last year when NNS signed a $150 million tanker contract with a major Greek shipping company-Eletson. Further evidence of this growing comeback is equally apparent in McDermott International's $830 million deal on 30 container ships destined for another Greek company. In addition, U.S. builders are actively competing for contracts with Ghana National Petroleum Corp. for power barges and Ingalls should receive final approval to build diesel submarines for Egypt under German license.

What has happened? The American comeback is based on a cheaper dollar, improving technology, and rising productivity. In addition, labor costs which account for about 40 percent of a finished vessel are being better managed. Today, U.S. labor costs average $17.65 an hour which compared favorably to Germany ($27.89 an hour) and Japan ($19.68 an hour). The only exception to the U.S. ranking is Korea which currently enjoys an average rate of around $8.00 an hour.[5] Other areas where improvements are apparent is in improved modular construction techniques, overhead costs, and entry into niche markets. Some of these markets lie in offshore drilling platforms and casino boats.

U.S. yards will be playing catch-up ball for some time. Title XI loan guarantees with extended terms provide leverage for U.S. yards to re-enter the volatile subsidy environment that exists globally. Recent innovation in this guarantee program now allows foreigners to use U.S. subsidies (Title XI) as long as they build in American yards; and this is exactly what attracted Eletson Corp.

U.S. Subsidies -- Title XI and the Jones Act

The ship financing program commonly known as Title XI was established in The Merchant Marine Act of 1936 to encourage U.S. shippers to build and convert ships in U.S. shipyards. In 1972, government involvement changed from mortgage insurance to guaranteed bonds. In 1994, the program was expanded to included overseas owners who could now enjoy the same 87.5 percent loan guarantees for 25 years as U.S. owners. In addition to construction, the $147 million appropriated for FY 1994 and 1995 could be used for reconstruction and reconditioning of commercial vessels in U.S. shipyards, U.S. shipyard modernization, and certain refinancing schemes. The $52 million requested for FY 1996 may be affected by ratification of the OECD agreement.[6]

The Merchant Marine Act of 1920--commonly referred to as the "Jones Act," prohibits foreign built, owned, or flagged vessels from operating in U.S. domestic trade routes.

Both of these subsidy programs will change if the OECD Agreement is ratified on January 1, 1996.

Foreign Subsidies

Historically, foreign shipbuilders have received varying levels of government aid. A 1995 study of U.K. shipbuilders conducted by Theisen Securities found that Spain and Denmark provide the highest "total benefit" at 22% to 30% of contract cost compared with 16% in the U.K. Most aid schemes included operating aid, a structure component, an interest component, and a tax benefit.

Today, the existing OECD terms have an advanced level of 80% of new building contract price, an 8.5-year term for delivery and a fixed minimum interest rate of 8 percent. After January 1, 1996, the new terms will increase the delivery to 12 years and interest will be based on a conference interest reference rate (CIRR) that removes most of the interest/currency component.

Ultimately, the OECD agreement will eliminate government subsidies for contracts, operations, and facilities improvements. In addition, some R&D aid, debt forgiveness, and discriminatory regulations and practices will also be eliminated. Finally, compliance will be ensured through member policing and enforcement.

International Negotiations: the OECD Shipbuilding Agreement

The Future of the Shipbuilding Agreement signed in late 1994 is a burning topic for U.S. shipbuilders and foreign shipbuilders alike. Once the Agreement is ratified, implementation should occur in Brussels. The ratified text stipulates that no direct, or indirect guarantees will be allowed. In addition, rules will be provided on "dumping." Certain types of aid will be allowed in areas of R&D, social securities for workers affected by lay-offs, and developing aid for third-world countries. Also contained within the agreement is a new annex for consensus agreement. The annex addresses fluctuations in the market by establishing a CIRR. Under this rate, governments will be able to provide funding to bank or pay the difference in bond rate to the bank. See *Appendix A* for further discussion.

Conclusions on Performance

--Ratifying the Agreement would be consistent with other U.S. trade policy focused on free trade.

--***Agreement will make the restructuring of the industry more painful***, but the costs of funding a substantial Title XI Loan Guarantees Program probably would not survive in the current political-economic environment.

INDUSTRY ASSESSMENT AND OUTLOOK

At first glance the outlook for the U.S. shipbuilding industry may appear bleak. But, after examining recent trends, the general requirements process, current international competition, and the defense industrial base issues, a different picture emerges. It is a picture characterized as complex, diversified, and challenging.

Trends

Trends affecting the U.S. and international shipbuilding industries range from significant changes in economic interdependence and individual government policies to

applications of Third Wave technologies and modern management practices.[7] ***Worldwide down scaling of defense establishments, globalization within industries, the resultant increased access to markets, and technology transfers between nations and between industries*** are all dominant themes with very practical consequences in international teaming.

Specific ***reactions to these trends*** helped frame the current circumstances:

--***Aggressive Japanese and South Korean firms*** building more world-class-yards and repair facilities in the face of global overcapacity.[8]

--The ***resurging European yards*** aiming at specialized markets for complex ship construction like cruise ships, ferries, and liquified natural gas (LNG) carriers.[9]

-- ***U.S. policy*** is aimed at converting a significant part of the very considerable capacity to compete successfully in today's global commercial market.

We believe that the Clinton Plan[10] is clearly a step in the right direction, but it does not go far enough in recognizing the problems of ensuring the DTIB while converting the rest of the industry, and it does not appear to recognize the highly variegated structure of the subsets of the naval and civil shipbuilding industries. The Clinton Plan should be expanded to encourage export of some military ships--an area of clear U.S. advantage we should exploit in order to preserve it. The export effort should focus on those classes of ships that are in demand by foreign governments unable to create or maintain a naval construction DTIB of their own. The Plan should also be strengthened by increased funding to support accelerated conversion to commercial shipbuilding by establishing an economic or tax structure which would help the industry modernize with automation-assisted proven management and material flow practices before we find ourselves constrained by the terms of the OECD Agreement we helped frame.

Comparisons with foreign shipbuilders clearly point toward the benefits in ***improved productivity associated with major modernization efforts in both manufacturing and management systems.*** Labor hours for compensated gross tonnage show the U.S. at a serious disadvantage.[11] Automation and information technology are the keys to overcoming this hurdle. *Charts 5 and 6* show the technology comparison and productivity comparison of leading U.S. and foreign yards. While there are gaps in the investments in hardware and software to be closed, the most immediate gains will come in overhauling systems for managing the flow of materials and labor through the yards likely to survive.[12]

From a business organization perspective, ***downsizing and appropriate national*** **and international corporate teaming** arrangement must be considered in those companies committed to survive if they are to remain viable in the long term.

We have seen how those foreign shipbuilders who have been forced into bankruptcy have, after government control and reorganization, focused on market *niches* and have become viable competent competitors in a global market. Countries with ***high labor rates have more success building for markets requiring complex ships and agility in responding to changing demands*** rather than competing with series production and low wage rate builders.

A relatively recent trend in shipbuilding is in responding to ***environmental considerations*** reflected in U.S. legislation and international agreements. The 1990 Oil Pollution Act has affected ship design and construction as well as creating increased demand for new shipbuilding and repairs for modification. These efforts regarding concern for the environment will continue and will drive up construction costs. The U.S. must continue to lead in the areas of informed, balanced environmental legislation, innovative shipbuilding practices which address international agreements to protect the environment, and appropriate trade policies to establish and maintain a level "playing field" in shipbuilding compliance. It is good policy and good business.

From a DoD perspective and in a post Cold War environment, the significant reduction in the naval shipbuilding program is a trend with significant impact on the entire industry. A return of large-scale naval shipbuilding is most unlikely. At the same time, ***replacing a lost shipyard takes many years.*** DoD estimates that it would take ***three to five years to replace a yard to build commercial ships and six to seven years to replace a yard that builds naval combatants. For nuclear capable yards, the feasibility of replacement is unlikely.*** For its part, DoD should know that excess capacity will not be maintained at private cost. Industry, on the other hand, must also realize that ***a cultural change may be in order to support both a naval and commercial industry in a competitive global environment.***

Trends in ship speed, port size, cargo handling capacity, and intermodal transportation systems will also affect both military and commercial shipbuilding. Although ship speed is critical to initial military mobilization, it may not be in the commercial world where throughput is often limited by port size and cargo handling capacity. There may be some market potential for fast commercial ships, but increased costs of production may tip the scales toward use of automation in timely scheduling of cargos to meet throughput constraints.

A final trend that will impact shipbuilding will be ***visionary bids for radically innovative ships and platforms designed for power projection*** that, if funded, will create demand in offshore industry ship construction--a sub-industry previously not heavily impacted by naval construction--but clearly in need of stimulation. Besides frontiers in naval applications for oil rig platform construction there are commercial application for ***specialized naval construction in the trends toward seabed and subsurface facilities for oil and gas production.***

Trends In Demand

There is a general agreement between leading ship builders and authoritative industry analysts that the majority ***(three fourths) of*** the ***demand for new construction for the rest of*** the ***decade will be from*** the ***need to replace existing vessels rather than an increase in the volume of trade.*** The base case projections focus on the deep sea fleet operating in harsh environments which will reach 25 years of age by the year 2001. This is approximately 6600 vessels, ***80 percent of which are dry bulk carriers and tankers.*** This is obviously the target of the Asian ship builders.

The one quarter of the ***projected demand that is trade-induced includes over half of the demand for chemical carriers and containerships as well as 80 percent of the gas carriers.*** These are the markets the Scandinavians aim at, and the ones the U.S. yards should be encouraged to enter. Consequently, the U.S. target of 3 percent of the projected aggregate demand over the next five years is more complex than getting 30-45 contracts of 1500 ships per year. It is really ***30-45 ships per year out of 295 chemical, 507 LNG and 1013 container ships needed over nine years -- or 15-20 percent of those specialized markets*** which is clearly threatening to our Scandinavian competitors.

The ***power projection requirements*** in the national military strategy have been quantified in the Department of Defense Mobility Requirements Study (MRS). This generates a ***well defined near and mid-term requirement for commercial ships.*** The satisfaction of this requirement represents significant large vessel construction for U.S. commercial shipbuilding. If properly utilized, this opportunity can be focused by both government and industry to help ***revitalize this industry through upgrading processes and technologies.*** By focusing government research facilities on these higher risk technologies for the mid and long-term ships with cost-sharing technology transfer to commercial research facilities and/or shipyards at the appropriate point of technology maturation, the U.S. can reasonably make a serious bid to reenter the commercial market.

Marketing

There were significant differences in efforts of U.S. and Scandinavian shipbuilders. Because the Scandinavian builders did not rely on government contracts, they were much more aggressive in their pursuit of commercial contracts. Only Sweden came close to approximating the U.S. reliance on the public sector. They, however, were more globally attentive as they marketed and sold their naval and commercial products to external customers--especially their advanced conventional submarines. See *Appendix B* for further discussion of marketing.

Constraint on Efficiency

The downsizing of the military infrastructure after the fall of the Soviet Union has affected the shipbuilding industry throughout most of the world. There have been radical changes in products, materials, organization, and markets within commercial shipbuilding in recent years. To compete in the commercial market, shipyards must concentrate on a narrow specialized segment of the market. This would drive the learning curve down for a particular segment so shipyards could become competitive. Staying competitive in general, however, requires a capacity for agility and a willingness to take on a new learning curve for an emerging niche market. There are several constraints that effect a shipyard's ability to become the choice of established shipowners who need a short delivery time and a quality product as well as a reasonable price.

Manpower. There must be a concerted effort to groom and retain the correct labor force mix that will provide high quality and quick turnaround as U.S. yards learn to operate on much shorter production timelines. Concentration of industry recruiting and training are not seen as a problem by most management. Downscaling gives them the opportunity to "select the survivors" within their work force. The improvement of the work environment to eliminate fumes, dust, noise, and radiation will enhance the image of modern shipbuilding. In-house training programs are also required to supply the highly skilled personnel that is required in today's shipbuilding as the technologies are upgraded. U.S. yards must drastically reduce the number of man-hours put in to each ton of ship produced if they are to achieve competitive costs of production. The investment in modern management of labor flow and materials flows through the yards will be a high payoff upgrade according to the Technology Survey of 1994.

Research And Development. Ships yards must continue to invest in R&D to reduce touch labor and the total cost of shipbuilding. This will increase the automation, technology, and computers that will play an increasing role in future shipbuilding. Federal laboratories should be incentivized to make a difference in the public assistance for yards making conversions.

Capital Investment. Advanced manufacturing technology is the cornerstone of worldwide competitiveness in the construction of ships. To remain competitive, a concerted effort to invest in new equipment, information systems, and facility upgrades is necessary. Details about where the upgrades are most needed are found in the Technology Survey of U.S. Shipyards 1994.

Unions. Labor forms 15 to 20 percent of the total cost of building a ship. Therefore, a good relationship between management and unions is important. Management and labor must form a team to promote highly skilled and well-motivated personnel, continuous improvement of productivity, and modern management and personnel participation models. The European yards are heavily unionized where as

the U.S. yards are not--in the first-tier and--in the second-tier.

Overregulation/Excessive Specifications

Onerous restrictive regulations that do not promote competitiveness in the commercial marketplace must be reviewed and eliminated wherever possible. Coast Guard and military design requirements force over-specification and consequent higher cost onto U.S. shipbuilders. The rest of the world is utilizing International Standards Organization (ISO) 9000 series specification in their ship construction.

Customer Allegiance

For the established shipowner, price is not the only factor. The established shipowner is interested in the shipyard's quality and the history of on-time deliveries. So, when a shipowner finds a shipyard with these qualities, it is very hard for a new shipyard to break into this relationship.

Impact of International Competition

There is strong competition around the world in the shipbuilding industry. Over 133 yards overseas can produce ships over 400 feet in length. The companies that will survive in this competitive market must fully employ technology to design and construct ships, reduce touch-labor cost, and specialize in a niche market. Japan and South Korea produce 60 percent of the world's shipping today.

The large market share foreign producers have taken will make it extremely difficult, but not impossible, for U.S. producers to enter the commercial shipbuilding market. Foreign producers have developed long term relationships with buyers and are in some cases vertically integrated with the buyers.

In the military market, foreign producers seem to have gauged better the needs of their export customer markets. They receive better government support, e.g. Denmark's active marketing program financed by the shipbuilders. Foreign builders also make ships that their export markets can afford.

The U.S. Defense Technology Industrial Base

DoD concern about the declining state of the shipbuilding industry focuses on the loss of a vital capacity of our Defense Technology Industrial Base (DTIB). Is the shipbuilding industry today as essential to our industrial base as it was, for instance, during World War I and II? If we can no longer afford to think in terms of an autarkic DTIB, are there selected segments of the shipbuilding industry that are more critical than others for ensuring future national security?

The real concern for preserving the DTIB centers around our capability to continue to produce complicated warships--both surface and sub-surface naval vessels. This concern has been best illustrated with recent arguments over the production of the Seawolf submarine. ***Submarines represent some of our most advanced technologies (especially critical nuclear and sound quieting expertise) which are an essential part of the DTIB that must be maintained. Nuclear carriers and Aegis cruisers also represent unique, complicated ships whose production requires a variety of engineering, design, and production skills that are an essential part of the DTIB.*** Virtually every shipbuilder we visited concurred that once these skills were lost, it would be very hard, if not impossible, to regain them in a national crisis.

In the current economic climate, we see several ways that may help preserve these essential DTIB skills. First of all, ***consolidation*** will help ensure the survival of this part of the DTIB. We foresee just two or three "major domestic players" remaining in the production of our most complicated warships. ***Cooperative ventures with our allies could also expand our technology base*** for commercial shipbuilding and diesel submarine construction through some "reverse technology transfers." ***It would also serve to accommodate their own DTIB concerns in this era of global downsizing and increasing pressure to reduce military budgets and forces.*** This will require some careful lifting of restrictions especially regarding the transfer of military technologies. This is also necessary if we are to ***become competitive in the international market for naval warships--which*** is another way we could help preserve the DTIB in this area. Selectively marketing our expertise in naval ships could ***create an international reputation for quality ships that are affordable.*** Many current problems with this would have to be resolved. For example, there is clearly an international market for non-nuclear attack submarines in which the U.S. does not compete because of anticipated technology transfer issues. Perhaps this is an area we need to re-examine through a more strategic lens. Similar markets exist for patrol boats and smaller surface combatants (corvettes, frigates, etc.).

The market for large bulk-carriers and other simple ships is dominated by countries like Korea and Japan, and the U.S. is unlikely to capture much of that world market. However, there is ***no critical need to establish and then preserve a large commercial surface DTIB capacity in this country beyond that required for the standing strategic sealift requirements.*** Should a military need above the planned strategic lift requirement arise, commercial ships would be readily available for purchase or lease from ship owners of several other countries. The downside of that is we would be put in a position of having to import high-priced goods during a preparation for and the conduct of war. So American yards now building naval vessels which decide to convert some or all of their capacity to commercial building should be encouraged and assisted to some extent to stabilize the work force of American yards and to generate export income. In that conversion process ***some capacity for regular and surge construction of strategic sealift*** will be realized. There is a security

interest in that, but it is not as critical because of the skill level and the uniqueness of some naval construction suppliers.

Another area of interest in this regard is the commercial applications of ***deep sea submergence technology,*** a highly specialized subset of the industry. This is an area where ***the U.S. had a considerable edge in years past, but is now in danger of losing to foreign competition (most notably the French and Japanese).*** The President's Plan is a five part blueprint that relies heavily on research and development. These are the same public and private facilities which develop deep sea technology for DSRVs and related systems. With care for technology transfer, ***there is a market for these technologies and these services in the offshore (oil and gas) industries in which the U.S. second-tier yards already have a niche. The trend towards deep (in excess of one thousand meters) exploration and exploitation by seabed based facilities bodes well for U.S. technologists in deep sea technologies.***

Government labs can continue to play a vital role in maintaining the health of the DTIB by actively pursuing both military and commercial applications. This means that government labs need to be more active in developing "dual-use" technologies and by encouraging commercial use of their facilities and services. (Indeed, this is an area of emphasis under the President's current shipbuilding initiative.) However, during several of our visits we found that commercial shipbuilders did not use government labs because either: 1) they were unaware of what the labs could do for them; 2) they found that the labs were not responsive to commercial needs; or 3) they believed the federal labs would not in anyway guarantee or warrant their work. Changing that perception could do a lot to preserve the technology portion of our shipbuilding DTIB.

The key to maintaining our shipbuilding DTIB can perhaps best be summed up by an observation made at one of the Scandinavian yards we visited. We choose to trim the "muscle" but keep the "brains"--the "brains" being the expertise, technical know-how, and the ability to recognize market niches where they could successfully compete. ***Our blueprint for maintaining the shipbuilding DTIB should pursue a similar "trimming the muscle but keeping the brains" philosophy.***

Foreign DTIB Support Potential

The U.S. has an interest in allied nations and major trading partners maintaining technology and industrial bases in order to ***complement the U.S. DTIB in the event of a surge in demand for naval and strategic lift construction.*** See *Appendix* C for amplification.

Conclusions on Assessment and Outlook

Conversion of some yards and some parts of other yards ***to commercial ship construction is in the national interest*** because of the need to stabilize the industry's work force and preserve an essential capacity to build warships, amphibious ships, and strategic lift ships.

Complex commercial ships that are not likely to have long production runs are the parts of the replacement and growth markets that are ***most like naval ship building.*** Contracts to build ***30-45 ships per year in these growth markets*** would keep most of the current base warm, but it will also mean ***encroaching on 15-20 percent of the specialized market currently held by Northern European yards.*** This complicates the potential for international teaming relationships where the most beneficial technology transfer can occur in both directions. Consequently, a ***mixed "capacity and product" targeting of market share for 30-45 ships per year is probably required*** to avoid threatening our most likely partners.

In any case, this 30-45 ship target is a very ambitious goal which ***can only be accomplished through "cooperative competition" with European yards*** interested in mutual technology transfer and access to the American market.

Firms in the third-tier are most vulnerable. The loss of a one-of-a-kind component or part producer could be very damaging to the DTIB.

Upgrading management techniques for flow of labor and material combined with information technology for CAD/CAM/CIM is at the heart of reducing the bloated U.S. man-hours per CGT produced. This is essential to reduce the cost of naval ships and to establish competitive production costs in the commercial market.

STRATEGY FOR 21ST CENTURY

The National Strategy should preserve the shipbuilding sector of the Defense Technology Industrial Base through:

--Reducing direct and indirect subsidies for shipbuilding by major shipbuilding nations while assisting U.S. shipbuilders to the maximum extent possible consistent with international agreements

--Leverage U.S. leads in information technology, microelectronics, and management technologies and protect them from predatory practices

--Facilitating the export of high technology naval and commercial ships

–Developing an agile, modern work force with state government and industry

–Encouraging corporate strategies for domestic and international teaming for mutual technology transfers and access to markets

RECOMMENDATIONS FOR GOVERNMENT

Actions for Near Term and Mid Term

1. Aggressively move to ratify the OECD Shipbuilding Agreement as soon as practicable. There will be no subsidy reductions without U.S. involvement and leadership. But U.S. industry will need assistance in making the transition to a competitive position in the commercial market.

2. Immediately refine and implement the Administration's plan for revitalizing shipyards with milestones and measurements for progress.

3. Review antitrust legislation and revise any which discourage domestic shipbuilder teaming efforts and vertical integration. First and second-tier builders may have to absorb critical suppliers in the third tier. Government loan guarantees may be required.

4. Review and eliminate all unnecessary governmental regulations on industry standards which do not contribute to the competitiveness of our shipbuilding industry. Adopt ISO 9000 series specifications and actively participate in the refinement of those international standards with U.S. safety and environmental standards.

5. Leverage R&D efforts at the national level to assist U.S. shipbuilders to develop and maintain a technologically based competitive advantage. Revitalize and upgrade the funding priority of MARITECH. MARITECH and ARPA should increase efforts and priorities to provide technology applications to upgrading, automating, and integrating U.S. production facilities and processes.

6. Review and remove dated OSD and Service policy restrictions on marketing and selling previously prohibited types of naval platforms (conventionally powered submarines) and systems to foreign customers. Encourage OSD and Service support for international marketing by U.S. firms.

7. Develop and pursue creative financing mechanisms that do not violate OECD provisions. Cost sharing schemes for R&D and funding for prototyping new integrated CAD/CAM systems that could serve both commercial and military building efforts are

examples.

8. Allow market forces to continue down sizing and right sizing the U.S. shipbuilding industry. "Encourage survivors" rather than "pick winners."

9. Develop and articulate a long term vision for the shipbuilding sector of the DTIB, which identifies a minimum acceptable capacity for naval and commercial construction for national security interests.

SUMMARY

The significant reduction in U.S. Navy shipbuilding continues to have a significant impact on the U.S. shipbuilding industry. Preserving the Defense Technology Industrial Base (DTIB) is important to this nation if it is to maintain those skills required to produce complicated warships and additional specialized strategic lift necessary for power projection.

If the U.S. shipbuilding industry is to survive, U.S. shipyards must modernize their management practices and technology so they can compete globally in the commercial market. They must engage in teaming with America's allies to expand their technology base. They need to concentrate on narrow, specialized segments of the market. Finding their market niches is critical to their survival in the commercial market. The shipyards must also focus their research and development efforts on innovative ways to reduce costs, to compress schedules, and to improve productivity and efficiency in both military and commercial shipbuilding.

The Government can assist by ratifying the OECD Agreement. This agreement will reduce most of the international shipbuilding subsidies and will help ensure generally fair international competition. Federal laboratories can assist the U.S. private sector by becoming leaders in ship design and manufacturing process engineering within the global market.

The U.S. Navy needs to examine alternative force structures which are not based solely on expensive, complex, and technologically advanced ships. The Service needs to consider the industrial base preservation imperatives inherent in buying and operating a few export model medium sized frigates and diesel submarines so that the Navy can support the marketing effort by demonstrated operational experience.

The global downsizing of the shipbuilding industry will continue for the next decade. Encouragement of international and domestic teaming for controlled technology transfer and mutual support of allied industrial bases is prudent policy. The key to maintaining the U.S. shipbuilding DTIB is for all the players to work together so that U.S. shipyards become the most up-to-date and cost-effective builders of complex ships in the world. A contemporary concern for foreign control of critical technologies

through foreign ownership and other technology losses to international industrial espionage must balance these initiatives.

We are not pessimistic in our conclusions. However, there are serious limitations to breaking into sectors where series production has been well established and entry for U.S. industries will be at an unacceptable public cost. There are also time lines on the implementation of international agreements which limit government assistance with entry--which if ignored could put the U.S. in an awkward position suggesting either negotiation in bad faith or ineptness, neither of which is in the national interest.

Some determined U.S. shipbuilders are going to survive this restructuring. They will do so because they learned how to compete in the commercial market by leveraging and preserving American advantages and learning from world class competitors. Others will survive because they deliver the best value for complex warships for the domestic and international markets. Some will find ways to do both.

NOTES

1. U.S. Industrial Outlook - 1994, p. 21-2.

2. Barry Hart Dubner, and Shirley Kath Waters, "Title XI Loan Guarantees: The Destruction of An Excellent Financial Aid Program for the United States Maritime Industry," Commercial Law Journal, Vol. 97, 1992, pp. 519-520.

3. Shipbuilders Council of America, presentation to the Industrial College of the Armed Forces, Washington,D.C., March 3, 1995, p. 5.

4. Ibid., p. 15.

5. Phalon, Richard, "Back In the Game," Forbes, December 5, 1994, pp. 58-60.

6. Shipbuilders Council of America presentation to the Industrial College of the Armed Forces, Washington, D.C., March 3 1995, p. 23.

7. Precis of Coakley's paper.

8. Precis of Sergei's paper.

9. Precis of Fletcher's paper.

10. Precis of Halter's paper.

11. Compensated Gross Tonnage (CGT) is used to provide a common yardstick to reflect the relative output of merchant shipbuilding activity in large aggregates. It takes into account influence of ship type, complexity and size on work content. OECD accepted. The comparative measure for assessing a yard's performance is laborcost of producing a CGT. Another measure is the number of direct worker man-hours required to produce a CGT.

12. Richard Lee Storch; John Clark; and Thomas Lamb. Technology Survey of U.S. Shipyards - 1994, Jersey City, N.J., The Society of Naval Architects and Marine Engineers, 1995, p.21.

BIBLIOGRAPHY

Andersen, Jorgen E. and Cato F. Sverdrup. "Can U.S. Shipbuilders Become Competitive in the International Merchant Market?" *Journal of Ship Production* Vol 9 No. 1 1993, pp. 43-50.

Aspin, Les. "Report On the Bottom-Up Review," Washington, D.C.: GPO, 1993.

Birkler, John; John Schank; Giles Smith; Fred Timson; James Chiesa; Marc Goldberg; Michael Mattock; and Malcolm MacKinnon. "The U.S. Submarine Production Base: An Analysis of Cost, Schedule, and Risk for Selected Force Structures." Washington, D.C.: RAND MDA903-90-C-0004.

Boisrayon, G. "Submarine SM 97 NAUTILE," *STCAN,* 1985, pp. 1-27.

Burns, Richard F. "Undersea Warfare--National, International Trends," *Sea Technology* November 1994, pp. 10-19.

Burns, Richard F. "Research Submersibles, Undersea Technologies," *Sea Technology* December 1994, pp. 23-33.

Burns, Richard F. "DoD Science & Technology Strategy: Investing in Security to Strengthen Economy," *Sea Technology,* January 1995.

Busby Associates, Inc. *Undersea Vehicles Directory 1990-91* 4th ed. Arlington, Va, 1990.

Chapman, Roger and David Lovelock. *Subsea Commercial Development - Market Opportunities: A Jane's Special Report.* Janes Information Group, 1992.

Department of Defense *Report to Congress On Submarine Industrial Base Issues* May 1994.

"Finnish Marine Technology: Yards Define state-of-the art," *Manne Log,* October 1991, pp. 29-30.

Graham, David M. "New Submersibles: Chicken or the Egg?" *Sea Technology,* December 1993, p. 7.

Graham, David M. "Refocus on Technology!" *Sea* Technology, December 1994, p. 7.

Jane's *Ocean Technology 1978* London, 1978.

Kennedy, Paul, *Preparing for the Twenty-first Century,* Vintage Books, 1994

Kiss, Ronald K. "U.S. Shipbuilding: Navy Perspective: Presentation to the National Defense University," February 10, 1995.

Slatkin, Nora. FY 1996 *Navy Submarine Modernization Plan,* ASN (RD&A) Testimony Before the Subcommittee on Procurement of the House National Security Committee, March 16, 1995.

Lazurit Central Design Bureau, Ministry of Industry of Russian Federation Shipbuilding Department. LAZURIT (promotional brochure, undated).

"Man of Steel," SCANORAMA April 1995.
A National Security Strategy of Engagement and Enlargement, The White House, February 1995.

National Academy of Engineering, *National Interests in as Age of Global Technology,* National Academy Press, 1991.

O'Rourke, Ronald. "Navy Seawolf and Centurion Attack Submarine Programs Issues for Congress," Washington, D.C. Congressional Research Service, Library of Congress, 1992.

Prina, L. Edgar. "Requiem for a Superpower," *Sea* Power, March 1995.

Radloff, Manfred. "Submersibles Conquer the Ocean Depths," *Vision Und Technik,* No. 6, Germany, 1991, pp. 170-174.

Redesigning Defense: Planning the Transition to the Future U.S. Defense Industrial Base. Congress of the United States Office of Technology Assessment, OTA-ISC-500. Washington, D.C.: US GPO, July 1991.

ST Special Report "Research Submersibles and Undersea Technology in Europe & Russia,"Sea *Technology December* 1993.

Sea Technology Buyers Guide Directory 1994-1995.

Seymour, Richard J., etal. *Research Submersibles and Undersea Technologies.* Baltimore: International Technology Research Institute, 1994.

U.S., *Industrial Outlook 1994.* Washington, D.C.: U.S. Department of Commerce ITA, pp. 21-1--21-8, 40-13--40-17..

Stone, Gregory S. "Japanese Ocean Research and Development," *Marine Technology Society Journal,* Vol 26, No 3, pp. 11-19.

Strengthening America's Shipyards: A Plan for Competing in the International Market, The White House, October 1, 1993.

Storch, Richard Lee; John Clark; and Thomas Lamb. *Technology Survey of U.S. Shipyards- 1994,* Jersey City, N.J.: The Society of Naval Architects and Marine Engineers, January 1995.

"Summary of Nuclear Industrial Base Studies, " Washington, D.C.: Department of the Navy Office of Program Appraisal, 1994.

Alvin and Heidi Toffler, *War and Anti-War, Survival at the Dawn of the 21st Century,* Little, Brown and Company, 1993

Alvin and Heidi Toffler, *Creating a New Civilization: The Politics of the Third Wave,* The Progress & Freedom Foundation, 1994

"Transportation, "U.S. *Industrial Outlook 1994.* Washington, D.C.: U.S. Department of Commerce ITA, pp 40-13--40-17.

Whitehurst, Clinton H., *The U.S. Shipbuilding Industry,* Past, Present, and Future, Naval Institute Press, 1986.

Whitman, Dr. Edward C. "Defense Conversion in Marine Technology," *Sea Technology, November* 1994, pp. 21-25.

Worldwide Submarine Proliferation In me Coming Decade. Washington, D.C.: Office of Naval Intelligence, 1994.

Shipbuilding Industries

Variegated Subordinate Industries

Attribute evaltd	Naval Surface	Naval Sub	R&D/Specialized	Commercial
Structure	1/3	2/3	2/3	1/2
Conduct	1/3	2/3	3/3	1/2
Performance	na	na	1/3	1/3
Trends Affect	1/2	1/2	2/2	1/1
Reqts Process	2/3	3/3	3/3	2/2
Cons on efficiecy	1/3	2/3	3/3	1/1
Impact Intl Comp	1/3	3/3	2/2	1/1
DTIB eval	1/na	1/na	2/na	1/na
For DTIB	na/3	na/3	na/2	na/1
Strat 21st cen	1/3	1/3	2/3	1/2
SELF ASSESSMENT				
1=well examined	US/Intl	US/Intl	US/Intl	US/Intl
2= covered				
3=marginally covered				
na=not applicable				

Shipbuilding IS 95 Coverage Chart 1

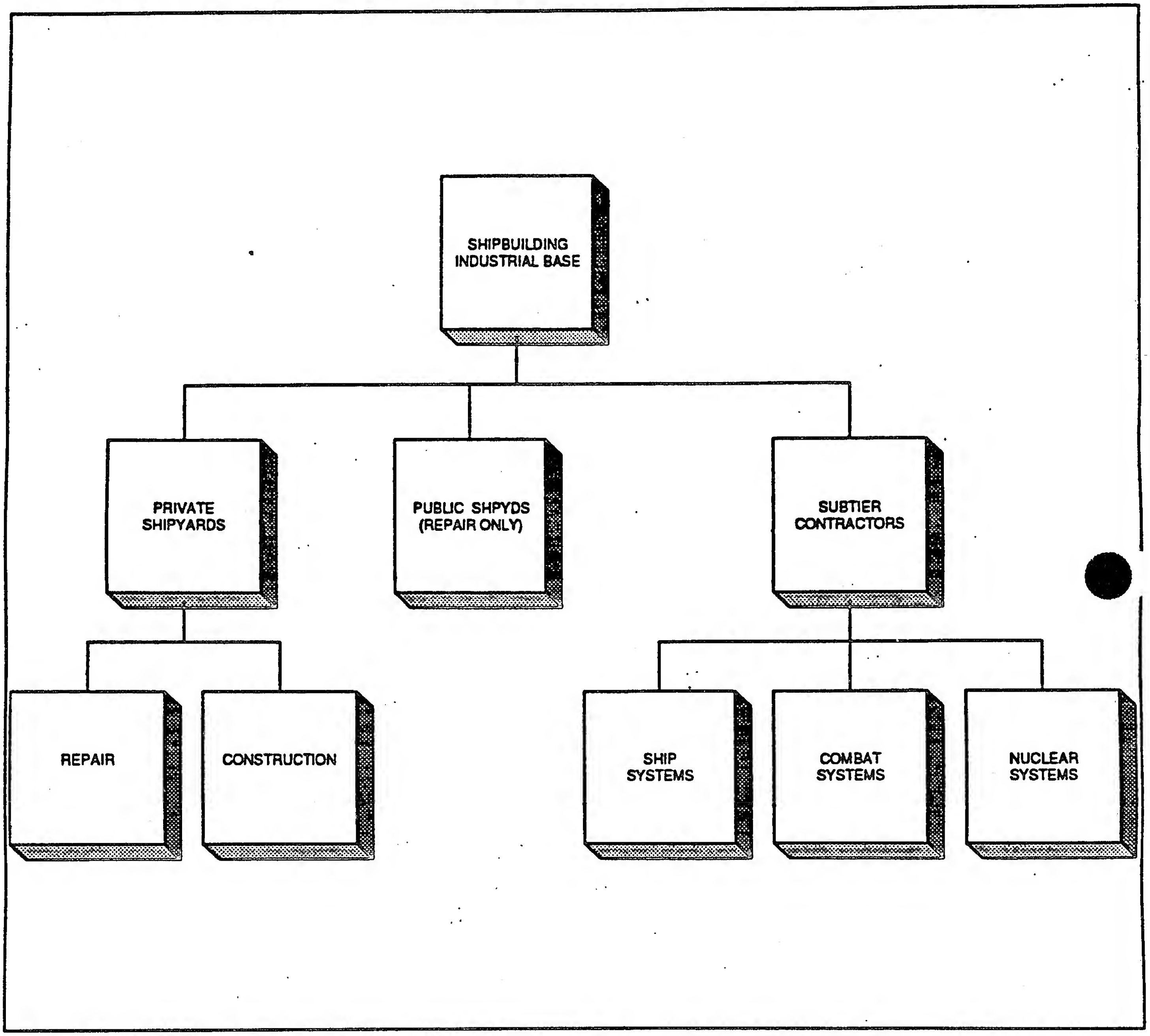

SHIPBUILDING INDUSTRIAL BASE
PRIVATE SHIPYARDS
PUBLIC SHPYDS (REPAIR ONLY)
SUBTIER CONTRACTORS
REPAIR
CONSTRUCTION
SHIP SYSTEMS
COMBAT SYSTEMS
NUCLEAR SYSTEMS

Chart 3

TIER 1 YARDS WITH NAVAL SHIP CONSTRUCTION CONTRACTS - JANUARY 1995

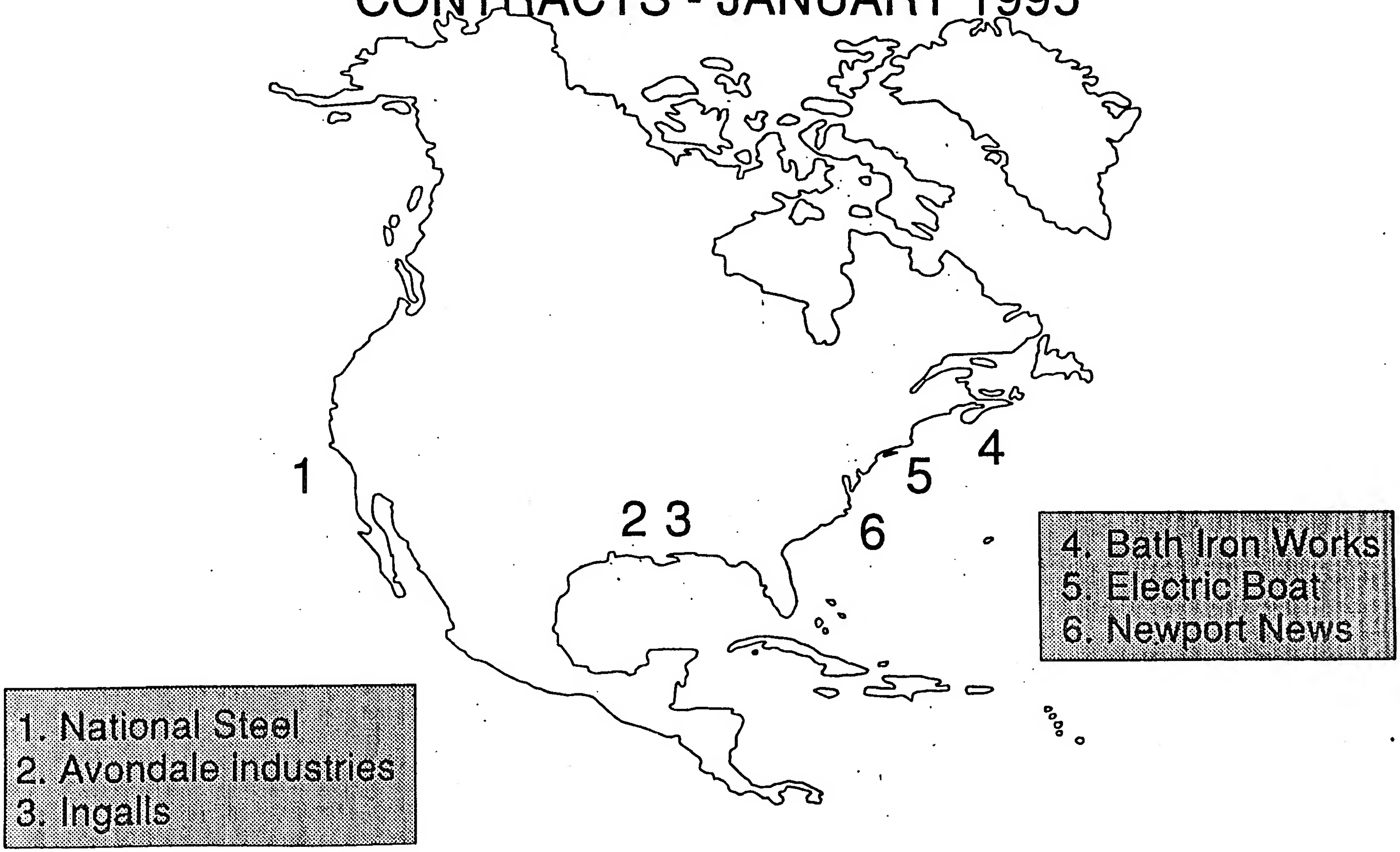


Table 1

NAVAL SHIP-BUILDING RATE

All Ships Over 1000 Tons

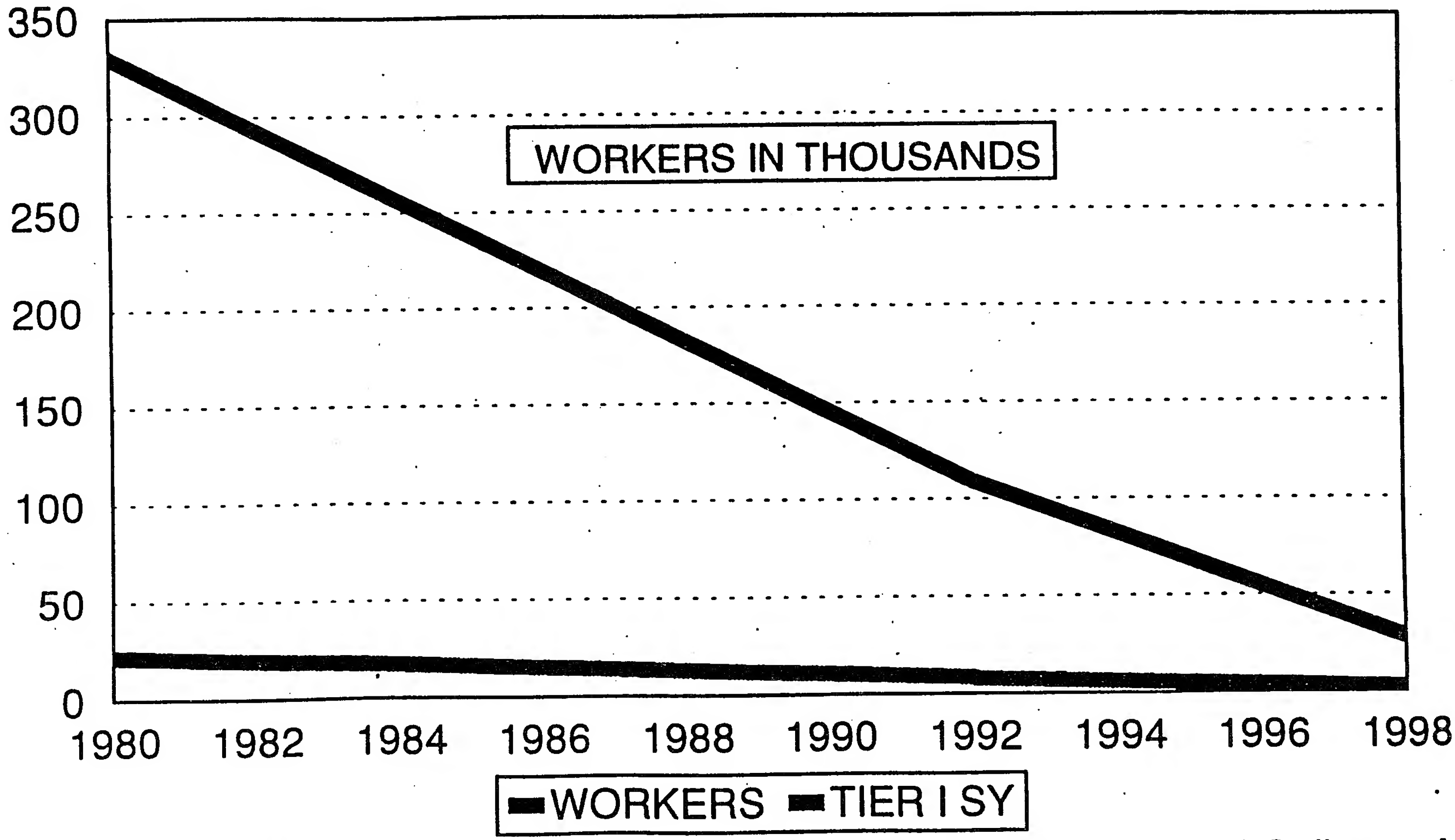
SHIPYARD	1960'S	1970'S	1980'S	1990-1994	1960-1994
AVONDALE	9	27	12	16	64
BATH IRON WORKS	16	7	25	10	58
ELECTRIC BOAT	26	13	31	14	84
INGALLS	13	42	24	13	92
NASCO	7	18	4	3	32
NEWPORT NEWS	30	17	16	13	76
TOTAL SIX YARDS	101	124	112	69	406
ALL NAVY	205	172	157	77	611

Birkler, John, Joseph Large, Giles Smith and Fred Timson, *Reconstituting A Production Capability,* Rand, 1993, p. 70

Chart 4

EMPLOYMENT TRENDS

Major Shipyards



Shipbuilder's Council of America presentation to the Industrial College of the Armed Forces, March 1995

Technology Survey - 1994

Chart 5

Can US Yards Compete?

Overall Technology Level

Yard	*US*	*Foreign*
1	3.2	3.0
2	3.4	3.3
3	3.4	4.1
4	3.5	4.4
5	--	4.5

Society of Naval Architects & Marine Engineers ,<u>Technology Survey of US Shipyards - 1994, p. 1-11.</u>

Technology Survey - 1994

Chart 6

	US Yard Ave	For Yard Visited Ave	All For Average	All For range
MH Wkd/Yr	1829	1805	1963	1,550-2,600
MH/CGT	184.8	40	88	17-180
Cost/Empl	52500	63455	48690	$11,290-104,960
Cost/CGT	5314	1121	1296	$697-$1,653

SNA&ME, Technology Survey Of US Shipyards - 1994, p. 1-17.

Chart 7
Shipping Nations by Ownership
A basis for integration?

- Greece *(1,4)*
- Japan *(1)*
- US *(1)*
- Norway *(2)*
- Hong Kong *(1)*
- China *(2)*
- UK *(1)*
- Sweden *(1,5)*

  - 1 65-90 foreign flag
  - 2 two thirds own flag
  - 4 20% of world's merchant fleet
  - 5 3% of world's merchant fleet

Scandinavian Shipping Gazette 4: 1995, p. 42

INDUSTRY STUDY

#16

SPACE

TABLE OF CONTENTS

PARTICIPANTS

Students

LTC William R. Canda, USAF

LTC Joseph A. Carretto, Jr., USAF

COL Raymond J. Cully, USA

LTC Daniel A. Cvelbar, USAF

CAPT Jean A. Dawson, USN

COL(S) Harrison C. Freer, USAF

Mr. Richard P. Gareau, GM-15, DIA

LTC Edward J. Hamilton, USMC

CAPT(S) Larry V. Judge, USN

Mr. John L. Nunziato, GM-15, D/AF

LTC Phil W. Parker, Jr., USAF

Mr. Edward S. Wilkinson, GM-15, CIA

Ms. Patricia J. Zarodkiewicz, GM-15, D/AF

Faculty

COL William T. Mayall, USAF

COL Mary S. McCully, USAF

COL John C. McKay, USMC

Dr. Abraham Singer, GS-15, D/A

PLACES VISITED

Domestic

National Photo Interpretation Ctr	Washington, D.C.
Naval Research Laboratory	Washington, D.C.
Applied Physics Laboratory, JHU	Laurel, MD
NASA Headquarters	Washington, D.C.
NASA Goddard Space Flight Center	Greenbelt, MD
NASA Kennedy Space Center	Kennedy Space Center, FL
McDonnell Douglas Aerospace	Cape Canaveral, FL
Lockheed-Martin	Cape Canaveral, FL
Rockwell International	Kennedy Space Center, FL
General Dynamics	Cape Canaveral, FL
National Security Agency	Ft. Meade, MD
45th Space Wing	Patrick AFB, FL

International Travel

European Space Agency	Paris, France
Director Generale Armaments	Paris, France
Societe European de Propulsion	Vernon, France
Centre National D'Etudes Spatiales	Paris, France
Aerospatiale	Les Mureaux, France
Matra-Marconi	Stevenage, U.K.
INMARSAT	London, U.K.
RKK Energia	Moscow, Russia
MZ Zvezda Design Bureau	Moscow, Russia
Cosmonaut Training Facility	Star City, Russia
MPO Machinostroenie	Moscow, Russia
Khrunichev	Moscow, Russia
Russian Space Agency	Moscow, Russia

BRIEFINGS

Lockheed Missile and Space	Santa Monica, CA
Defense Intelligence Agency	Bolling AFB, D.C.
COMSAT Corp	Gaithersburg, MD
Lockheed-Martin	Bethesda, MD
Hughes	Reston, VA
Rockwell International	Washington, D.C.
TRW	Redondo Beach, CA
National Reconnaissance Office	Washington, D.C.
Orbital Science Corp.	Reston, VA
Ballistic Missile Defense Office	Washington, D.C.
National Air Intelligence Ctr	Wright Patterson AFB, OH

ABSTRACT

This paper analyzes the health of the United States Space industry and makes recommendations for a national strategy and vision designed to promote the U.S. as the preeminent supplier of launch, satellites, and services among the spacefaring nations. The paper addresses the structure, conduct, and performance of the U.S. space industry and highlights areas of international competition. The extensive role of the Federal Government is discussed, including areas requiring policy review and change. Two specific sectors, launch and applications, are reviewed in greater detail. International cooperative efforts and areas of competition are addressed. The paper concludes with recommendations for revitalizing the space industry. The recommendations include the definition of a national space vision and strategy; institutionalizing a standing forum to implement the strategy and monitor progress; creating a government-industry partnership for a new launch vehicle, using the SEMATECH model; rationalizing regulation and law; stabilizing the federal budget process; increasing international cooperation; improving warfighter support; and supporting dual use of commercial imaging, navigation, and communications systems. Adoption and implementation of these recommendations would strengthen the U.S. space industry and help restore its previously unchallenged supremacy among the spacefaring nations.

INTRODUCTION

"The contemplation of celestial things will make a man both speak and think more sublimely and magnificently when he descends to human affairs." Cicero

Since civilizations began, space has captured the attention of man, in fear, awe, and wonder. The celestial bodies were the focus of religious rituals and the cause of unexplained phenomena. In later centuries, space became the focus of scientific thought and investigation, culminating in a series of technical achievements many thought impossible. While the sense of wonder and adventure is not lost on current space efforts, it has been complicated by geopolitical competition, international cooperation, military applications, and the profit motive. These contrasting visions of space have created tensions which both promote and hinder individual space programs and dilute the necessary public support for a robust program balanced among the competing needs of the United States..

Following the 1957 launch of Sputnik, the first artificial satellite to orbit the Earth, the U.S. responded with fear and awe at the Soviet's technical and political accomplishment and its potentially destabilizing military applications. The space race began in earnest while the U.S. struggled to balance the civilian and military approaches to space, but geopolitical competition was a main force behind the program's goals. In 1961, Russian cosmonaut Yuri Gagarin was the first human to orbit the earth, leading President John F. Kennedy to challenge the American people to achieve a moon landing before the end of that decade. As the spectacular moon landing in 1969 clinched the technological leadership in space for the U.S., it also signaled a turning point, as space programs were competing for constrained domestic resources against an unpopular war and the continuation of the Great Society programs.

This resource competition continues today, as the nation attempts to balance the Federally supported civil and military space programs against entitlements, tax reductions, international obligations, and domestic needs. This competition is further complicated by the conflicting motives of the Federal and private sector stakeholders in the space industry as they struggle to balance national security needs, the desire for worldwide market share, and the profits needed to remain as viable corporations.

The theme of competing interests will reappear throughout the paper, as we discuss the space industry, its structure, conduct and performance, and the significant role of the U.S. Government in establishing policies which both support and unintentionally impede the industry's progress. We will also discuss two vital sectors of the industry, space launch and applications, and review the international environment. Finally, we will provide some recommendations we believe will strengthen the U.S. space industry in its multiple roles of providing for national security, its place in the global market, and in pursuit of scientific advancement.

THE SPACE INDUSTRY

The space industry can be defined as the capability supported by a number of industries including launch system manufacturing, satellite manufacturing for remote sensing, telecommunications, navigation, defense and space exploration, and all supporting infrastructure. Both public and private interests are included, with the Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA) the predominate public sector players. While federally supported space programs are more often in the public spotlight, the private sector is driving the industry's growth, primarily through commercial telecommunications and their support to international service industries, such as finance.

Segments of the space industry are categorized as Aerospace (guided missiles, space vehicles, propulsion, and parts), Telecommunications (satellite services), and Telecommunications and Navigation Systems (satellite communications systems [both ground and space segments] and navigation [reconnaissance and surveillance equipment]. Space Commerce, a significant segment of the industry, includes space launch, satellite services, remote sensing, space-based materials processing, commercial research and development, infrastructure, and insurance. The Federal Government is the predominant player in the Aerospace and Navigation segments, largely due to the national security applications of these systems. The private sector plays heavily in the services and ground segments of the Telecommunications and Navigation Systems sector, the industry segments with the greatest commercial applications.

The space industry also has considerable overlap with the avionics, electronics, telecommunications, aerospace, and munitions industries, complicating both federal level data gathering and advocacy of policies designed to help specific segments of these industries.

Scope and Trends

The space industry captures approximately one-half of one percent of the U.S. Gross Domestic Product (GDP), and the U.S. Government is the largest single consumer in the market. Using data provided by the Department of Commerce and the Aerospace Industries Association, revenues in all segments total approximately $60-70 billion annually, reflecting only a minor decrease in real terms in the past two years. The Aerospace segment, specifically guided missile and space vehicles, had over $27 billion in revenues in 1993, with over 50% of the revenues generated by DoD activities. As such, this segment has been declining, but at a slower rate than the overall DoD budget. Telecommunications, while only a small part of the industry ($2 billion), is the fastest growing segment in the industry due to the boom in mobile communications and the expansion of the worldwide market. Satellite services saw a 23% increase in revenues between 1992 and 1993, and similar growth is expected in

1994 and throughout the decade. Satellite communications system hardware is worth about $2.7 billion, with ground segments accounting for over 75% of the revenue. While difficult to specifically identify the space segment of navigation systems due to the amalgamation of maritime, aviation, landbased, and spacebased equipment, this sector has had significant growth due to the expansion of the Global Positioning System (GPS) in both military and civilian applications. Space Commerce, the sector controlled by private industry, has been calculated at $6.5 billion in revenue in 1994, over 20% growth from 1993 captured largely in the satellite communications manufacturing and services segments.

Internationally, the U.S. dominates the space market, and export earnings were over $1.6 billion in 1993, one of the few industries where the U.S. had a trade surplus. This trade surplus is largely due to the U.S.'s hold on the worldwide commercial satellite manufacturing and services markets. In the guided missile and space vehicle segment, the U.S. holds over 60% of the international market, over 69% of worldwide satellite manufacturing, and the majority of satellite services. However, international competition is growing, especially in launch services, from Russia, China, Japan, and the European Space Agency, and a number of new, smaller players such as Israel, Brazil, and India. Many nations are aggressively pursuing indigenous space industries to ensure self reliance and to enter what many view as a potentially lucrative international market; the U.S. must take steps to ensure its long term competitiveness in this market.

Structure

The space industry is characterized by oligopolies, largely due to the limited number of buyers (primarily the U.S. Government, and in some cases, other nations), very high entry barriers, and a recent spate of mergers and acquisitions. The two primary segments, space launch and satellite manufacturing, highlight the limited number of producers in the industry. In satellite manufacturing, five companies dominate: GM Hughes (which holds over 50% of the worldwide commercial communications satellite manufacturing market), Martin Marietta (now Lockheed Martin), Loral (an international consortium), TRW, and Rockwell. TRW and Rockwell are primarily in the military satellite market. An example of consolidation is reflected in the history of what is now Lockheed Martin. Martin Marietta purchased General Dynamics Astrospace Division (producers of Atlas and Centaur launch vehicles) and GE Astrospace (producers of the Global Positioning Satellite (GPS) IIR and the Defense Satellite Communications System (DSCS)), and in March 1995, merged with Lockheed. These horizontal and vertical mergers were spurred by the shrinkage in DoD demand, and the resulting excess capacity. Further shrinkage is anticipated in the wake of the $10 billion Lockheed Martin merger; industry representatives speculate that at least one of the four Lockheed Martin satellite manufacturing plants will close by year end. These industry consolidations are evident among our

international competitors as well, as shown by the Matra-Marconi marriage and the Daimler-Benz Aerospace consolidation in Germany.

In the expendable launch booster segment, two manufacturers are the primary competitors, each specializing in a particular model, while some smaller firms are competing for niche markets or entering partnerships with the larger firms. Lockheed Martin captures most of the U.S. heavy lift with the Titan IV and Atlas boosters, while McDonnell Douglas is the primary competitor in small to medium lift with the Delta II. McDonnell Douglas recently unveiled a plan to upgrade to the Delta III, with a payload capacity of 3,800 pounds to geostationary transfer orbit - putting it in a competitive position with the Atlas medium lift vehicle. One of the relatively younger and smaller firms in the business, Orbital Science, has been very successful in capturing the niche market for lightweight scientific launches with the aircraft-launched Pegasus rocket and the more powerful Taurus model.

Internationally, the U.S. is facing tough competition in space launch, primarily from the European Space Agency's (ESA) launch agent, Arianespace, which currently holds over 60% of the worldwide geosynchronous market. The emergence of the non-market economies, Russia and China, on the launch scene has complicated the market, as they have been able to undercut the U.S. and ESA on price and launch schedule. The international launch environment will be addressed in more detail later in the report.

Conduct

The influence of the U.S. Government in the space industry drives much of its conduct as many management and labor practices are driven by U.S. law, and the federal acquisition process establishes everything from subcontractor goals (small and disadvantaged or minority owned businesses) to allowable risk to final profit margin. Management practices have been impacted through the use of total quality principles, but company survival has not been assured due to the dramatic shrinkage in the Government market, driving many of the recent mergers and diversification efforts. Prices are inelastic in most segments, but show normal competitive pressures in communications services where more suppliers are found. Research and development has declined, largely due to the reduction in Federal spending. In some areas such as launch infrastructure and boosters, capital investment has been limited, as few new products or major modernization efforts have been Federally funded for a number of years.

One example of government impact on industry conduct is evident in the expansion of the GPS market. There were over 350,000 users of GPS in 1993, and the commercial market for aviation, land, and maritime navigation use remains largely untapped. FAA Administrator David Hinson announced earlier this year that GPS user fees would not be collected for ten years. This free access should help to spur market

development. U.S. companies currently hold over 80% of the GPS hardware market and the U.S. is expected to maintain market share due to its technology edge.

While the U.S. holds the technological edge in many areas of space, the decline in federally funded research and development and capital investment puts that advantage at long-term risk, especially when competing against government subsidized or non-market economy products. The high capital investment rates in the countries of the Organization of Economic Cooperation and Development (OECD) and in Japan are a direct result of their high national savings rates, savings which provide low-cost capital to the private sector. Without aggressive action by the U.S. Government to restore investment in R&D, the U.S. may see a loss of competitiveness in the long term.

Performance

The space industry, as a high-technology, leading edge business, has high wages and a high quality product but declining sales and employment. Factors contributing to the decline include the downsizing of NASA and DoD requirements, streamlined processes, the production of quantitatively more effective systems, the introduction of new international competitors, and the many mergers seen in the industry. Federal and commercial space industry employment declined almost 20% during the past five years; this downward trend is also evident among all our European and Russian competitors.

However, mergers may improve the profitability of some companies. Lockheed Martin anticipates a rapid recovery from the one-time, high cost of consolidation (anticipated to be over $6 billion) and stock prices have risen since the merger.

Product cost in some sectors remains high, such as satellites and space boosters; but in navigation, the miniaturization and broader applications of GPS have decreased prices and increased production. Expansion into new markets, such as China, the Pacific, and Latin America, will drive the cost of equipment and services down simply due to the large number of buyers, especially for communication services. Many developing nations are expected to leapfrog from no service to cellular service as their primary telecommunications medium. The industry recognizes that early entry into the market to capture customers will only be profitable in the long term if they are not undercut by lower prices or improved services of later entrants.

THE ROLE OF GOVERNMENT

The role of government in the health and competitiveness of the space industry is felt in a wide variety of areas, through explicit policy and resource decisions as well as the implicit outcomes from other federal policies and actions. Diverse actors include the Departments of Justice, Commerce, and Transportation, the Security and

Exchange Commission, members of Congress, and state and local constituents. The numerous players in the Federal and local arenas complicate space policy for all the stakeholders.

The Federal budget deficit plays a large role in the space program, as the growth of the deficit is the primary cause of the fiscal constraints felt by the military and civilian space programs. Defense and domestic discretionary programs have taken the brunt of the budget reductions required to reduce federal spending. In real terms, DoD procurement declined 75% between 1989 and 1995, and NASA's overall budget was reduced over 35%. Other reductions have affected basic and advanced education, university research, and basic science, all important factors for the space industry. With the Federal Government as the predominant buyer of space assets and services, industry demand has fallen dramatically as both R&D and procurement funding evaporated, despite growing commercial sales. Even with the deficit shrinking in relation to the U.S. GDP, it is unlikely there will be any significant real growth in the Federal space programs before the turn of the century, only heightening the need to maximize today's shrinking investment dollars.

The United States' low national savings rate exacerbates the budget reductions engendered by the federal deficit. The cost of capital is high, as most of the available savings are used to pay interest on the federal debt, not to capitalize industry. This high cost of capital increases the investment risk of many firms, and forces a focus on short-term return on investment, rather than on long-term profitability. The U.S. currently has the lowest capital investment rate of all OECD countries, jeopardizing our long-term competitiveness in industries such as space, which require aggressive research and development and costly physical and human capital. One example of the capital-intensive nature of the industry is Motorola's Iridium commercial mobile telecommunications system, which will require over $3 billion in capital to launch a 66-satellite constellation.

Policy development, regulation, and law are other significant areas impacting the space industry. Trade policy, particularly export controls, affects our ability to compete internationally. The Missile Technology Control Regime, important for national security purposes, provides a framework for export control, but the administration and waiver process is convoluted, cumbersome, and time consuming, and undercuts the ability of U.S. firms to successfully compete in the world market.

Tax law, particularly the elimination of the capital investment write offs, does little to incentivize firms to invest in R&D or capital improvements. Anti-trust policy prevents timely consolidation in the industry, and precludes many teaming arrangements. In many cases, it has been easier for U.S. firms to team internationally rather than with other domestic firms, a situation that improves our international cooperation at the cost of strengthening our domestic producers. International teaming has been supported, shown by the approval of the Lockheed Khrunichev

Energia (LKE) joint venture to launch commercial satellites on the Russian Proton rocket, and the recently announced Sea Launch joint venture for sea platform launches led by Boeing Commercial Space Co., in cooperation with Kvaerner A.S. of Norway, Energia of Russia, and NPO Yushnoye of Ukraine.

The high cost of doing business with the Federal Government also discourages some firms from competing for government work. Motorola, a leading commercial satellite and GPS equipment manufacturer, finds no need to compete for federal work, as the cost of accounting systems, oversight, and bureaucracy are too high for the low profit margins acceptable in federal contracting. Vice President Gore's National Performance Review estimated that the cost of doing business with the Federal Government was 20% more than the cost of the actual work performed, with very little value added. Unless this changes, other world class producers may leave the federal market, undercutting our ability to produce high quality, leading edge technologies in a low cost, timely fashion.

The Federal Government must change the way it does business to ensure the health and continuity of the space industry. Dual use and cooperative efforts must pave the way of the future, and they can occur without degrading the national security of the nation as they improve the economic security of the nation. There is little political will or resources available to continue to rely on single-use military systems. Extensive commercial satellite communications, high resolution imagery, and weather systems can be a force multiplier for the military, once we learn to plan for, and accommodate, both national security concerns and the private sector's market share concerns within the operational concept of a system. Dual use of the Global Positioning System is a prime example of this need.

Space systems require a long term focus on research and development, basic and graduate level education, infrastructure, and technology. Private and public investment in these areas is necessary to support our national role in space. A bipartisan consensus must be developed in Congress to support these factors, provide appropriate resources, and design policies to incentivize, streamline, and reward innovative behavior.

SPACE INDUSTRY SECTORS

The once-vaunted space capability of the United States is in decay, and the U.S. is no longer the unchallenged leader in space launch technology. The current launch infrastructure is so inefficient, unreliable, and expensive that it not only threatens our dominant position in the ever-expanding arena of commercial space operations, but also risks our ability to meet the military and economic objectives upon which our national security is based.

The launch situation the U.S. faces today has its roots in the Apollo program. Winning the race to the moon was both the end of the beginning, and the beginning of the end of U.S. dominance in space launch. The U.S. rushed into space using available ICBM technology, largely from the 1960s, anticipating replacement systems which would exploit more advanced technologies. During the budget crunch of the 1970s, exploratory programs were cancelled, yet the promised new launch system survived, committing the United States completely to the Space Shuttle. Congress, believing the Shuttle to be more economical, directed that all expendable launch vehicles (ELVs) except the tiny Scout rocket be phased out of use. Production lines for the Delta and Atlas rockets began to close in the early 1980s. The Air Force, however, was still concerned that a problem with the new Shuttle could prevent the DoD from placing critical satellites in space. It decided to develop a heavy-lift version of its Titan booster to "complement" the Shuttle. After the Challenger tragedy in 1986 and the Titan explosion a few months later, DoD quickly initiated a "Space Recovery Plan" to regain access to space. The resulting U.S. space policy called for a return to a "mixed fleet" of ELVs and Shuttle flights to assure future space launch capability. By 1988, the U.S. was conducting launch operations again, but with basically the same launch vehicles as before-the rush to get back into space did not allow for much consideration of cost efficiency or technological advancement. This lack of cost control and the speedy reliance on available technologies are key factors in the expensive life cycles and high operational costs of today's space launch systems.

However, more than just the boosters are antiquated--the entire launch infrastructure is out of date. This includes launch pads, payload processing facilities, and launch control centers. While there have been some enhancements, the basic facilities, processes, and equipment are over 30-years old. Overhauling such a large infrastructure has been prohibitively expensive.

While the United States was recovering from the launch crises (shuttle and Titan) of 1986, several individual nations and international consortia accelerated their space launch industries to "fill the void" left by the recovering U.S. launch industry. Russia began offering its huge military launch "industry" to the commercial market, with approval of the U.S. President. While Russia relied upon the boosters and facilities of the former USSR, China and Japan developed modern launch facilities and booster rockets. China has already begun launching satellites commercially on its "Long March" rocket, and Japan has responded to bids to launch INTELSAT and INMARSAT satellites on its new H-2 rocket. But the most serious challenge to the U.S. space industry comes from the consortium of nations in the European Space Agency (ESA).

Beginning in the late 1970s, ESA developed the Ariane family of launch vehicles, and development continues today on a medium-lift vehicle (Ariane IV) and a heavy-lift vehicle (Ariane V). The French company, Arianespace, is ESA's launch agent. After studying U.S. technology and processes, Ariane built their systems for

efficient payload processing and launch operations. Since beginning commercial operations in 1982, they have become the U.S.'s major competitor in launch services. In 1994, Ariane provided 62 percent of the commercial launch market for medium and large satellites to geosynchronous orbit. By contrast, U.S. providers commanded only 36 percent.

U.S. launches are generally unreliable and expensive when compared to other nations. In terms of cost, estimates abound, but the DoD's 1993 Space Launch Systems Bottom-up review put the cost of launching a payload into low-earth orbit at approximately $16,000/pound. The cost for an Ariane launch is roughly $8,000/pound, while the Russians and Chinese can launch for about $4,000/pound. These numbers should not be taken as absolute values, but as relative differences in cost. Reliability and ability to meet launch schedule also play important roles, especially when launching satellites that cost upwards of $100 million dollars each. Although the Space Shuttle has a reliability rate of 97 percent, U.S. ELVs have a success rate of just 80 percent. Russia and Arianespace demonstrate a 90 percent success rate. At least one U.S. satellite manufacturer claimed success rate not cost as the reason his company chose Ariane over an American launcher.

The problems of high cost and poor reliability are not surprises to the U.S. space community. Numerous studies highlight the need for a new launch system to reduce cost, increase reliability, improve responsiveness, and add more advanced operational characteristics. Despite clear recognition of the problem, little has been done to solve it.

The Future of U.S. Space Launch

The United States has already focused considerable attention on the need to enhance our space capability. Vice President Gore's Space Policy Advisory Board called for numerous changes to the way the U.S. conducts business in the space arena. The most significant recommendation is to "develop and make operational a modern, low-cost launch system."

Industry has begun the move toward competitive operations. Orbital Sciences Corporation developed the Pegasus booster and its more powerful derivative, the Taurus booster. Both are now in commercial operation. Although these smaller vehicles do satisfy some requirements, the primary need is for a new medium-lift space launch capability: 82% of the DoD space lift requirements fall into this category, as do most commercial payloads. And there is still a requirement for heavy-lift capability to orbit DoD's largest payloads and NASA's space station components. But while the Government has begun several programs to meet these requirements, a lack of commitment has already delayed operations of more economical systems at least a decade.

The National Aerospace Plane (NASP) was a three-phase program to develop and demonstrate a fully reusable, Single-Stage-To-Orbit (SSTO) test vehicle. Unfortunately, due to budget constraints and technical concerns, Congress terminated the program in 1994. Although Congress believes space launch is a critical issue, they are reluctant to fund it is modernization citing the lack of a coherent national strategy on future launch system direction. Congress may be right, but they are also part of the problem, as they generate program and funding instability and provide conflicting guidance on which direction to pursue.

In 1990, the Ballistic Missile Development Office (BMDO) began working with McDonnell Douglas to build a totally reusable, SSTO vehicle as a cost effective way of launching its "Star Wars" payloads. A sub-scale, sub-orbital vehicle (the DC-X) was built, and it completed three successful flights. Congress appropriated additional money for the program, but split funding and responsibility between the DoD and the Advanced Research Project Agency (ARPA). The future of the program has been in jeopardy, however, because of inter-agency competition, various space modernization studies currently underway, and uncertainty over the administration's overall space strategy.

Meanwhile, several programs were begun over the last decade to develop new, lower cost ELVs built around common components, advanced processing methods, and greatly simplified operations. Yet each were cancelled after initial investments in studies and technologies. Ironically, Ariane V is exactly the type of launcher these programs sought to produce.

If the U.S. is to become competitive in the increasingly important business of space launch, we must stop contemplating alternatives and initiate a new launch vehicle. Cost estimates range from $6-20 billion. A NASA study concluded it should transition to a fully reusable, SSTO launch vehicle that would capitalize on technologies developed under the NASP and the DC-X programs. The new vehicle would replace NASA's Shuttle and DoD's Titan IV heavy-lift ELV. Interestingly enough, NASA does not believe it will have sufficient funding to build an operational vehicle. It hopes that the private sector will develop the vehicle, with the Federal Government guaranteeing a certain number of flights per year as an incentive. This approach may work, given industry's desire to have cheap access to space.

Clearly, the incentives, ideas, and technologies exist to build new launch vehicles. The major obstacle to progress is a coherent launch strategy, developed in concert between the federal stakeholders and the commercial sector. If the Administration provides the vision, Congress may be more willing to provide consistent funding, or to support the creation of a government-industry partnership which could. That would enable America to develop the new family of ELVs, a goal since the late 1980s. In addition, NASA could build the next generation manned vehicle it needs to support the space station. Together, this provides the U.S. with a robust,

complementary capability, competitive in the world market.

Space Industry Sectors: Applications

A wide variety of space based applications exist, including telecommunications, earth observation, and weather, but imagery and navigation systems are the two main U.S. areas of concern, largely due to their military and commercial applications. These two sectors will be discussed in detail below.

Commercial Imagery: Landsat and SPOT

Originally conceived as a means of providing unclassified panchromatic and multispectral data to a wide variety of customers and organizations, the Landsat program originated with NASA in 1970. In addition to the multispectral data that Landsat provides, one of its major advantages is its ability to image large areas of territory at one time. The amount of this coverage is approximately 100 square nautical miles (185 km). This feature offers a great advantage for military planners and others who need to analyze and monitor large amounts of territory for targeting purposes, determining ingress/egress mission planning packages, and for surveillance of potential conflict areas where U.S. forces might be engaged.

Current plans call for NASA to build and operate the next satellite in the series, Landsat 7, while the National Oceanographic & Atmospheric Administration (NOAA) will operate the ground segment of the system. In 1994, DoD and NASA disagreed over who should pay for Landsat 7 and a proposed high resolution add-on system, and DoD terminated its role in the program. Landsat 7 is not scheduled for launch until 1998 and will be equipped with only a 15-meter panchromatic sensor and 30-meter multispectral sensors.

To manage the flow of data and the day-to-day operations, the Earth Observation Satellite (EOSAT) company was formed in 1984 as a joint venture of Hughes Aircraft Company and Martin Marietta Corporation. In 1985, EOSAT won a Government contract to be the sole company allowed to sell data from the Landsat systems. The Federal Government ceased funding EOSAT's contract in 1992 following a Commerce Department study that indicated it would not be a profitable business. EOSAT has operated the Landsat system on its own for the past 3 years with about $18 million of sales per year. In a recent interview, the CEO of EOSAT stated that business was growing about 20% annually since 1992. EOSAT has taken advantage of the alliances it has forged with governments worldwide who had satellites but were searching for joint marketing arrangements to provide data to their customers. Japan, India, Russia, and the ESA are now part of EOSAT's network of satellite providers. A recent agreement with Antrix Corporation, LTD., of India is expected to generate $75-100 million by 1997 and will contribute about $1 billion to the potential $3-$6 billion remote sensing market in the next decade.

The major competitor to Landsat in the foreign market is the SPOT program, developed by the French Government in the late 1970s. SPOT was operating its first satellite by 1985. It was a success from its earliest days due in part to a resolution in the 10-meter range, one-third of the current Landsat system's resolution. The French also have plans to launch the military Helios satellite during the summer of 1995. Although this system will provide imagery in the 3-5 meter range, the French reportedly have no plans at present to market this data to commercial customers. Future SPOT programs in the late 1990s will continue to be marketed to customers on a worldwide basis and will provide data in the 5-meter range.

In addition to the French, the Russian Government entered the market several years ago with 2-meter resolution imagery which is currently being marketed by EOSAT.

Recent Developments In Commercial Imagery

The future direction of commercial imagery systems was resolved, to some degree, a year ago, when President Clinton announced a policy implementing guidelines on foreign access to remote sensing capabilities. This policy was designed to protect the national security of the U.S. in three ways. First, the Department of Commerce, in consultation with State and Defense and the Intelligence communities, was authorized to license firms to operate commercial remote sensing systems on a case-by-case basis. Second, the State Department could allow the export of remote sensing systems more advanced than what is currently commercially available. Third, it would restrict the export of certain sophisticated items found on the U.S. munitions list.

This policy also recognized the potential for job creation and economic expansion in commercial remote sensing. It ultimately led to the licensing of five U.S. commercial remote sensing systems created by Lockheed CRSS, Worldview, Astrovision, Ball Aerospace and Eyeglass, and a consortium of Orbital Science, GDE, and EIRAD. They will offer a variety of 3-15 meter resolution, panchromatic or multispectral images, with some products on the market by late 1995.

The field has narrowed to four with the recent announcement by Ball Corporation and Worldview Imaging Corporation to merge Worldview with Earthwatch Inc, Ball Aerospace and Comm Group, a newly formed remote sensing subsidiary. Ball was awarded a one-meter license by the Commerce Department in September, 1994, and Worldview was granted a 3-meter license in January, 1995. According to their press release in January 1995, Earthwatch's initial satellite constellation will consist of a two satellite series, each having single-band panchromatic and multispectral sensors. The first satellite has 3-meter panchromatic resolution and a 15- meter multispectral sensor, and is scheduled for launch in early 1996. The second satellite is scheduled for launch in late 1997, and has one-meter panchromatic

and four-meter multispectral sensors. The spacecraft is reported to have on-board data storage capabilities for later down-linking to three ground stations, including a new data archive and processing facility headquarters in Colorado.

Based on the cost of market entry and uncertainties about the actual market for imagery, it seems likely that of the firms originally granted licenses, only one or two will survive the competition and actually build and launch systems. The other companies will undoubtedly end up as subcontractors or joint venture partners in these efforts. Other sources also indicate that the market, at least as configured today, will only support one, or at most two, firms in the remote sensing business.

Global Positioning System (GPS)

GPS provides worldwide, 24-hour, all weather, precise navigation information to both commercial users and warfighters. GPS' military applications were evident during the Gulf War, where ground, air, naval, and special operations forces successfully used the system. Additional military applications are being developed, such as the use of GPS guidance systems to make dumb bombs into smart weapons, and enhancements to provide precise time synchronization and navigation broadcast messages. As new applications are being developed, DoD needs to take greater steps to incorporate GPS use into military doctrine, training, and exercises to increase familiarization with the systems in realistic environments and design greater exploitation of GPS for wartime scenarios. With even more extensive use of GPS anticipated in the near future, many concerns arise over priorities, operations, and the mixed use of civilian and military technology. Security concerns for U.S. troops become paramount when potential adversaries can navigate and target with the same accuracy as U.S. forces, and these concerns must be addressed in doctrine, planning, training, and force modernization/enhancements.

As mentioned earlier, the U.S. has captured over 80% of the worldwide commercial GPS market, and expects to maintain market share (primarily due to technology lead) as commercial and military application expand exponentially during the next decade. The civilian market includes applications supporting all modes of transportation, surveying, precise time transfer, and geodesy. As there is no fee for GPS services, user access and applications are likely to increase. In fact, the International Civil Aviation Organization (ICAO) and the Federal Aviation Administration (FAA) are reviewing GPS as an international standard, but require assurances that the DoD would not restrict access during times of conflict. The Russian Glonass navigation system is also a player in the international civil aviation debate, but there continues to be a high degree of skepticism about the viability of the Russian program, as well as recognition of valid U.S. national security concerns.

Key to the potential dual use of GPS is selective availability--the ability to degrade or turn off GPS signals. Selective availability is critical to protection of U.S.

forces but its use risks undermining the reliability of the commercial signals. If worldwide applications and the resulting market share are dependent on the reliability of a highly accurate signal, selective availability may be damaging to U.S. producers. However, many performance enhancements, such as Differential GPS, receiver set improvements, particularly implementation of receiver autonomous integrity monitoring (RAIM), and carrier phase ranging, are being driven by demands of the civilian markets. These improvements will also be available to the military user, and likely at a lower cost than if developed only for the DoD user. The Department of Defense must find ways to incorporate the advances of the commercial sector into DoD capabilities, while finding the means to deny those capabilities to an adversary. Lower cost and greater GPS availability can be a great advantage to DoD, but not at the risk of U.S. forces. This will be a delicate balancing act as economic, political, and national security concerns come into conflict.

THE INTERNATIONAL SPACE ENVIRONMENT

Cooperation Issues

Many nations, both large and small, have committed scarce resources to become participants in space; some only as shareholders in international satellite consortia, like INMARSAT, and others fully committed to becoming launch, satellite and service providers. While individual corporations and public entities are concerned with returns on investment, many nations participate in space for national security reasons and international prestige.

These conflicting rationales foster an arena ripe for conflict between competition and cooperation, between corporations, and at the geopolitical level. These conflicting desires are evident in inconsistent policies which both encourage and encumber cooperative efforts (by firms and nations), and an ongoing international debate over the appropriate use of resources to support cooperative efforts (vice a purely free market approach). The International Space Station is the cornerstone of nationally sponsored international space cooperation, and the focus of the debate for many national participants.

Space Station Alpha, a scaled-down version of the U.S. designed Space Station Freedom, is the sole remaining large scale international cooperative space program. Current participants include the U.S., Canada, France, Germany, Italy, Japan, and Russia. The participants see their involvement as a low-cost way of expanding their national space programs, particularly for expensive manned programs and for large scale orbital research and development. Anticipated returns include high technology innovations for peaceful purposes, greater cooperation between nations leading to fewer political and cultural barriers, and building mutual confidence. Alpha will also provide the experience and expertise needed for further space exploration. Needless

to mention, participation in the program provides contracts and jobs, and supports each nation's high-technology industrial base.

Cooperation will remain necessary as long as each nation must balance their investments in space with other national requirements; that is, for the foreseeable future. Currently, no single spacefaring nation has the domestic will to invest the vast resources required for a sole attempt at a space station, return to the moon, or any major planetary exploration. Resources must be pooled, and national strengths and capabilities exploited for maximum gain. Some nations, such as Japan, are increasing their space programs, but the chart below highlights the relatively low investments the major spacefaring nations are making in their programs.

	Space Budget in U.S. $ ($ in B)	GDP ($ in B)	% Space/GDP	Space $/Person
USA	$14.2	6,738	0.21	54.6
Japan	2.7	5,574	0.05	21.5
France	2.5	1,434	0.17	42.7
Germany	1.0	2,303	0.04	12.2
Canada	0.3	518	0.05	8.8

As shown on the chart, the U.S.' investment in space overwhelms that of all other nations combined. This high level of investment, plus our technological superiority, supports a leadership role for the U.S. in cooperative space efforts. However, there is little bipartisan support for this role, and current Congressional deliberations may undercut funding for the Space Station, curtailing U.S. involvement and leadership in this effort. Elimination of Space Station funding will not only be a severe blow to the U.S. manned space program, but would further damage our credibility as a viable, long term cooperative partner.

Competition Among Space Faring Nations

As addressed earlier, competition in the space industry is growing, as nations develop indigenous capabilities for both national security and economic reasons. Nations such as Israel and India have focused on space for primarily national security reasons, developing some limited launch and satellite manufacturing capability. However, India is beginning to expand into the commercial areas of space, primarily through their satellite communications networks and regional telecommunications applications.

Brazil, with it's favorable geography and relatively low cost labor, is being wooed by a number of nations, including Russia, for the development of a new equatorial launch base. The Russians, in particular, are searching for alternatives to

their own northern launch facilities and wish to reduce their current reliance on the launch sites in Kazahkstan which they no longer control.

China, like Russia, is in a competitive position with the low-cost launch services of the Long March medium lift vehicle. Despite some recent launch failures, many private U.S. companies, such as Hughes, plan on using the Long March for launching commercial satellites. The low cost of the launch service makes buying a satellite on orbit affordable for many less developed nations intent on improving their telecommunications capability. With their non-market subsidies, China could become a formidable competitor in the future.

Japan trails the U.S. in spending on space, but is the second largest investor in pure dollar terms, and plans on increasing its investment throughout the decade. The newly tested H-2 vehicle has great potential in the market, but will be stymied by a limited launch window due to restrictions on overflight of off-shore fishing areas and generally poor weather in the region. In discussions with U.S., European, and Russian space industry officials, many viewed Japan as the greatest competitive threat in the next decade.

The conflicting trends of competition and cooperation will make establishing coherent policies and programs difficult for U.S. stakeholders. It is likely that both cooperation and competition will continue between nations, individual corporations, and various national/private joint ventures. Space investment is simply too costly and too high risk for any stakeholder to plan on dominating a single sector.

RECOMMENDATIONS FOR A NATIONAL SPACE INDUSTRY STRATEGY

". . .time for this nation to take a clearly leading role in space achievement which in many ways may hold the key to our future on earth."

This statement, made over 30 years ago by President Kennedy, is the foundation for our recommendations. We believe that the U.S. must take action to secure its leadership in space, in hopes of providing for the security and prosperity of our nation. The following recommendations, designed to forward this leadership goal, are based on the observations, research, and discussions of the ICAF Space Industry Group:

1. Define the National Space Vision and Strategy. Given the competition between geopolitical, military, scientific, civil, and commercial applications of space, and the limited resources to pursue space programs, there must be an overarching vision of the role of space in the nation's future. This vision would provide a strategy for Federal resource allocation and policies, and a vector for commercial investment to follow. The lack of vision has contributed to the eroded public and Congressional support of space programs, further jeopardizing long-term resources essential to support the space progams' contributions to the nation's security, economic prosperity, and international prestige.

2. Institute a standing forum, similar to the National Space Council, to implement the strategy and monitor progress. This council should be the interagency forum for debate and discussion over priorities, as well as provide international and commercial interface. Responsibilities would include:

- monitoring the space vision for continuity with U.S. goals and the goals of our international spacefaring partners
- developing integrated polices for military, scientific, civil, and commercial applications of space
- orchestrate the acquisition of federally owned capital assets, such as launch infrastructure and space assets, and ensure no duplication of facilities or assets with the commercial sector
- oversee the formulation of Federal space budgets and help defend the budget to Congress and the public
- monitor the performance of the space programs and their support of the national vision and strategy

3. Create a government-industry partnership for a new launch vehicle, using the SEMATECH model. SEMATECH was an alliance of DoD and private industry designed to pool funding and technology to regain U.S. preeminence in the worldwide semi-conductor market. SEMATECH's model would provide a highly leveraged public-private consortium for a new launch vehicle, infrastructure, and associated services.

Federal funds for spacelift R&D, currently about $1.3 billion, would be consolidated and used as the Government portion of the matching funds needed to begin the space version of SEMATECH. NASA, DoD, and other agency funding would be matched by contractors to develop a new, competitive launch system for the world market, an investment estimated at over $5 billion. No new Federal funds (above the existing program) would be requested, making the venture politically viable in the current fiscal environment. The Government seed money reduces both risk and the amount of capital required from the individual firms involved. However, with their own capital and credit at risk, the corporate participants are highly incentivized to push technology, shorten timetables, and minimize lifecycle costs. This proposal would synergize Federal and private technical expertise, cut costs, and provide a viable profit motive, allowing the Federal Government to get out of the commercial space launch business once world market dominance is regained.

To protect this infant industry while a new booster is under development, the U.S. would need to continue quantitative limits on the non-market priced Russian and Chinese launches and qualitative policy restrictions on the use of other nation's systems until the new system was ready to compete in an open market. At that time, the current restrictions on using non-U.S. launchers would be eliminated, including the use of demilitarized ICBMs, allowing for fuller, more open competition in the worldwide market. This increased competition should decrease costs, and could create additional demands for on-orbit systems not currently cost effective. This approach could also be effective in transitioning Shuttle and Space Station operations to the private sector.

4. Rationalize Regulation and Law. The Government role in space is omnipresent and conflicting, and cumbersome policies create inefficiencies and disincentives which the industry cannot afford. Tax law, anti-trust, and tort reform are essential to encourage an efficient and effective private sector (sized to fit market demands), reduce the cost of capital formation, and incentivize an increase in independent research and development (IR&D) and capital investment. Streamlining the myriad of export (and import) controls would improve U.S. international competitiveness by allowing more aggressive pursuit of markets and allow U.S. firms to buy technology and processes from our competitors. International trends toward consolidations, teaming, and partnerships must not be undercut by red tape. Acquisition reform must be pursued for improved efficiency in the Federal sectors, and a cost-benefit balance of environmental regulations must be sought. While national security and environmental concerns must be assuaged, a more appropriate balance must be found if U.S. firms are to compete in the world market.

5. Increase Stability and Discipline in the Federal Budget. The lack of progress in reducing the amount of the Federal deficit and the exponential growth in entitlement programs diminishes the ability and willingness of the Federal Government to resource programs, including those needed for future gains in technology, national security, or

international competitiveness. Tight resource constraints also reduce Federal investment in education, health, and infrastructure, basic factors which are the foundation of high tech industries. While it is unlikely that federally funded space programs will see any increase in funding in the near future, existing programs would be more effective with greater program content and budget stability. As shown by the turmoil of the launcher modernization efforts and the frequent changes in the Space Station program, the annual instability of DoD and NASA programs causes inefficient management decisions, unutilized sunk costs, inconsistent or duplicative guidance, and generates confusion in the private sector who are attempting to support the Federal programs. Providing program and budget stability requires cooperation from both the Administration and from the Congress, in determining at the national level what programs have merit, and providing bipartisan consensus in the support of those programs.

6. Increase International Cooperation. Planetary exploration, manned space, and space science efforts are costly endeavors, and provide a ripe opportunity for increased international cooperation. President Lyndon Johnson commented, "As man draws nearer to the stars, why should he not also draw nearer his neighbor? As we push ever more deeply into the universe, we must constantly learn to cooperate across the frontiers that really divide earth's surface."

Current efforts underway for Space Station Alpha include participation by the U.S., Russia, Canada, UK, France, Italy, and Germany. The Space Station is currently the only large international cooperative space effort after the cancellation of ESA's Hermes program. This broad-based effort is viable where costly, national campaigns are no longer politically acceptable because of constrained resources. The cooperative effort reduces the cost of each nation's participation, accesses the best leading edge technology, and encourages close relationships between scientific, military, commercial, and policy communities. The results of the multinational effort will provide far greater benefits than any single national effort. The U.S. must remain strongly committed to its leading role in Space Station Alpha to strengthen cooperative efforts, retain leadership and prestige, and improve its credibility as a partner. Challenges and difficulties of cooperation are evident, but the long-term dividends will offset the costs and time of managing the partnerships.

7. Improve Warfighter Support. Space is a force multiplier. National and commercial space assets have proven, in peacetime and in war, to provide valuable intelligence, weather, warning, imagery, communication, and navigation information to the warfighter. Greater tactical applications of space, and incorporation of space systems into doctrine, training, and joint/combined exercises, will capitalize on the extensive investments made in national systems. However, the U.S. must have the ability to deny hostile forces access to these data through encryption of both national and commercial assets. Agreements must be pursued with other nations and commercial providers to allow for this possibility.

Research and development of theater missile defense (TMD) systems should continue while the U.S. pursues discussions with the Russians on the applicability of the 1972 Anti-Ballistic Missile (ABM) Treaty to TMD testing and deployment. There remain considerable political, technological, and economic concerns over these systems which must be resolved before operational testing and deployment can occur. However, these systems will provide increased protection to U.S. forces at the theater level, and establish the basis for defense of the U.S. homeland against limited missile attack.

8. Greater Use of Commercial Imaging, Navigation and Communications Systems. The Department of Defense needs to ensure that the planned commercial imaging, navigation, and communications systems, while primarily intended for the civil market, can also be tailored and focused to support the growing needs and demands of the warfighter during peacetime and crisis. Resources will not be available for single use military systems, and commercial systems can act as force multipliers, expanding the existing military capacity. Policies and procedures should be created to ensure that this operational partnership supports both the warfighters' needs for secure information and the commercial providers' needs for continual service to their customers. In addition, under the aegis of the U.S. security policy banner, the U.S. must facilitate the commercialization of cutting-edge, potentially-classified satellite technology for potential dual use.

REFERENCES

Aerospace Industries Association, **Aerospace Facts and Figures, 1994-1995,** Aerospace Industries Association of America, Washington, D.C., 1994.

Department of Commerce, **1994 Industry Outlook**, Washington, D.C., Government Printing Office, 1994.

Commercial Space Transportation Study: Executive Summary, Prepared by Boeing, General Dynamics, Lockheed, Martin Marietta, McDonnell Douglas, Rockwell. April 1994.

Cully, R. John, Col, USA, **Sustaining the Intelligence Industrial Base: Issues and Alternatives,** Industrial College of the Armed Forces unpublished manuscript. April 1995.

Fabian, John, President ANSER Corporation, Presentation to the Industrial College of the Armed Forces, 1 February 1995, Washington, D.C.

Foley, Theresa, "How Ariane Does It," **Air Force Magazine**, February 1995, Arlington, VA.

ICAF Class of 1994, **ICAF Industry Study #14, Space,** Ft. McNair, Washington, D.C., May 1994.

Krug, Linda T., **Presidential Perspectives on Space Exploration**, New York, Praeger, 1991.

Radzanowski, David P., and Marcia S. Smith, **Space Launch Vehicles: Government Requirements and Commercial Competition,** Congressional Research Service (CRS) Issue Brief, Washington, D.C., July 7, 1994.

Rosenberg, Barry and Catherine Macauly, Civil Space Survey: TELECOM Demands Fuel the Boom." **Aviation Week and Space Technology**, Washington, D.C., August 8 1994.

INDUSTRY STUDY

#17

INFORMATION TECHNOLOGY

TABLE OF CONTENTS

PARTICIPANTS

Students

LTC Brian Brodfuehrer, USAF
LTC Randall E. Bruch, USA
LTC Michael E. Carroll, USMC
John Christensen, DLA
LTC Bradley Copeland, ANG
LTC Jan R. Frye, USA
COL Frankie D. Hoskey, USA
Wardell J. Lindsay, NSA
LTC Terry L. Mapstone, USA
CAPT Michael Maurer, USN
COL Tony McCormack, CAF
Susan E. Pfeiffer, D/A
LTC Donald E. Ryan, Jr., USAF
CDR Steven K. Shegrud, USN
Thomas J. White, Dept. of State
Eli T. Williams, Jr., DISA

Faculty

COL Richard Altieri, USA
Dr. Robert E. Howard, SES-06, DOD
Dr. Robert Lyons, SES-04, DISA
COL Steve Thacher, USA

PLACES VISITED

Domestic

AirTouch
Apple
Bell Atlantic
Bellcore Labs
Bolt, Beranek and Newman, Inc. (BBN)
General Telephone and Electronics (GTE)
GT Global Telecommunications
Intel
MicroSoft
Oracle
Rational Software
Space Systems Loral
Stanford Telecommunications
Sun Microsystems
TRW
Xerox Palo Alto Research Center (PARC)

International

Asian Technology Information Program
AST Research (LTD)
American Telephone and Telegraph (AT&T) Asia/Pacific, Inc.
AT&T China
Fujitsu
Guangdong Provincial Post and Telecommunications Administration
Guangzhou Communications Institute
Guangzhou Wire Communication Equipment Factory
Harris Corporation
International Business Machines (IBM) Japan
Japan Ministry of Posts and Telecommunications
NEC
Nippon Broadcasting Corporation (NHK)
Nippon Telephone and Telegraph (NTT)
Northern Telecom (Asia)
Shenzhen Post and Telecommunications Bureau
Sony

GUEST SPEAKERS

American Chamber of Commerce
ASD(C3I)
AT&T
Brookings Institution
Communications Week International
Computer Sciences Corporation (CSC)
Congressional Staffs
Defense Information Systems Agency
Department of Justice (DOJ)
Digital Equipment Corporation
EDS
Electronic Industries Association
Information Technology Association of America
National Cable Television Association
National Institute of Standards and Technology (NIST)
Office of Management and Budget (OMB)
Office of Telecommunications, Department of Commerce
Software Engineering Institute
Teledesic
Trusted Systems, Inc.
U.S. Consulate, Guangzhou
U.S. Consulate, Hong Kong
U.S. Embassy, Japan
U.S. Forces, Japan
United States Telephone Association
Wheat International Communications

INTRODUCTION

Information technology (IT) permeates every aspect of our lives. We can phone or fax from our cars, pay our bills from home, shop from home, even work (telecommute) from home--not to mention communicate with almost anyone worldwide via the Internet. There are microprocessors embedded in our cars, our appliances, our watches, and our shavers. In fact, in 1994 personal computer sales exceeded television sales in the United States for the first time ever.

IT is also transforming every major industry in the world through advanced technologies for manufacturing processes, global telecommunications links, and electronic data interchange. The rate of IT innovation continues at an incredible pace spurred primarily by consumer demand, the size of the potential market, and of course, the potential for profit. Intense competition is keeping consumer prices low.

The IT industry is metamorphosing. Technological advancements are causing a convergence within the industry, blurring the traditional IT industry market sector boundaries of computer equipment, computer software and networking, information services, telecommunications equipment, and telecommunications services. For example, cable companies are starting to enter the communications market, local and long distance telephone companies want to get into each others' markets, and wireless services are competing with both, but are currently constrained by limits on capacity as well as regulatory and legal restrictions. New terms are being coined to describe these new IT market sectors--"infotainment", 'interactive multimedia', 'video-on-demand', and 'edutainment' to name a few, but the key words within the industry today are 'smaller, cheaper, and faster'.

Maintaining our competitive edge and world leadership in the IT industry is essential to the economic health and survival of the U.S. economy. IT is vital to U.S. national security in another way--it is an enabling industry, and if not already so, is quickly becoming the very heart and lifeblood of American national infrastructure. As we increasingly rely on IT for operating our financial markets and financial institutions, emergency response systems, and even the training, readiness, and capabilities of our military, we cannot ignore the issue of information security...who can, or already is, replicating, modifying, or disrupting our data and to what end?

Without a doubt, IT is a strategic industry. This paper will assess today's information technology industry, explore its future, and suggest relevant policies that will shape and enhance U.S. national security.

INDUSTRY OVERVIEW AND COMPETITIVE ASSESSMENT

Although the IT industry is redefining itself, industrial sector categories have not yet changed. We will, therefore, discuss the economic health and U.S.

competitiveness in the IT industry (which accounted for $478.2 billion in revenues during 1994) in terms of the five traditional sectors: Computer Equipment; Computer Software and Networking; Information Services; Telecommunications Equipment; and Telecommunications Services. The appendix provides details on the 1994 performance of these sectors and projected performance for 1998.

Computer Equipment: This industry sector includes electronic computers, storage devices, computer terminals, and computer peripheral equipment. U.S. sales grew by 11% to $60.0 billion in 1994 and growth continues to be led by consumer demand and industry's quest for improved productivity. The mix of 1994 shipments favored computers vice peripherals reflecting the demand for cheaper and increasingly more powerful work stations. Fierce competition has forced restructuring causing industry employment to drop by over 10,000 to 190,000 by the end of 1994. This reduction, coupled with business process reengineering efforts, produced the largest 1994 profit improvement of any IT industry sector. U.S. firms continue to dominate and currently command 60% of the worldwide market.

The 1990s are ushering in an era of personal access to a vast array of interactive information and entertainment services ("infotainment"). Strategic alliances are being formed between computer, electronic, and telecommunications companies to develop new and innovative ways to deliver large amounts of graphic, video, sound, text, and data in digital form. The long- term survival of computer equipment firms depends on their ability to innovate, invest in R&D, attract and retain a highly skilled labor force, move manufacturing facilities off-shore as required, and to commercialize their technological advances quickly into marketable products.

Computer Software and Networking: This IT sector, which includes prepackaged software and networking, generated $53.4 billion in revenues for 1994 and is expected to grow steadily over the next several years. The U.S. is extremely competitive in this sector and also represents the largest single-country demand (over 50%) for prepackaged software. Japan is second with about 10% of total demand, followed by Germany, United Kingdom, and France. Total sector revenues should reach nearly $58.7 billion by 1998. Application solutions leads the sector with expected annual revenues of nearly $22.6 billion.

Computer Software. In the short term, U.S. software revenues, which reached $34.5 billion for 1994, are expected to continue to grow at a rate of 10% annually. Non-U.S. firms, however, are expected to grow at a faster pace. Although this is an increasingly important revenue share factor, long-term projections suggest a sustained double digit rate of growth for U.S. firms. The main competition in operating system software will continue to be between OS/2 and Windows and trends towards interoperability are expected to continue. Emerging technologies include interactive multimedia, virtual reality products, and object oriented software.

Networking. Local Area Networking (LAN) includes network interface cards (NICs), inter-networking devices, intelligent wiring centers or hubs, and terminal servers. World wide revenues for LAN were $7.4 billion in 1994, up 23% over the previous year. The PC LAN network operating software market grew 26% to $2.8 billion and the number of licenses installed grew to 2.9 billion. International demand for LAN usage also continues to grow, most notably in Europe and in Asia. Small user group operating systems (Local Area Networks and Wide Area Networks) grew the fastest and the world-wide market for intelligent wiring centers ("hubs") grew 37% to $2.3 billion. Hubs or concentrators are the primary building blocks of networks, combining different configurations and media into one concentrator.

Information Services: Information services companies generate, process, and distribute data. They also assist other organizations in developing systems, software, and plans to perform such functions. The three components of the Information Services sector of the IT industry are: electronic information services; data processing services; and computer professional services. More than 1 million persons are employed by over 25,000 information services companies. 1994 revenues for this sector were $135.8 billion in 1994 and are expected to enjoy continued growth.

Electronic Information Services. 1994 revenues were $15.6 billion, an increase of 15% from 1993. Revenues come from business users of information for financial management, research, marketing, purchasing, and general business information. On-line services had 2.8 million business subscribers and 3.4 million consumer subscribers in 1993. About 65% of the information is delivered on-line, however, CD-ROM accounted for over 12% of the market. Other forms of delivery include audio text and Internet. In 1993, 2221 companies produced 5210 databases and 824 companies provided on-line services and over 3200 databases were available on CD-ROM. U.S. companies are strong overseas, holding 35% of the European market for example, as they provide some of the most advanced and diversified services. In the short term, growth is expected to continue although prices will fall as competition increases. The long term outlook calls for sustained annual growth of 15% for the next 4-5 years.

Data Processing and Network Services. 1994 revenues were $53.6 billion, an increase of 15% from 1993. Data processing companies perform such services as credit card authorization and billing, data entry, medical claims process, payroll processing, and data center management. Network services are used for electronic data interchange (EDI), delivery of electronic mail, electronic file transfer, and data base access. U.S. firms are maintaining their world leadership in this sector primarily because of the wide spread use of data networks and the wide variety of reliable services and products (over 25% of total revenues are from foreign customers). Growth is expected to continue at a rate of 14% annually for the next 4-5 years with network services contributing the most growth due to increased use of EDI.

Computer Professional Services (CPS). 1994 revenues were $66.6 billion, an increase of 9% from 1993. CPS includes systems integration, consulting and training, and custom programming. Annual growth is expected to continue at just under 10% and revenues will reach $94.0 billion by 1998. About 4100 U.S. corporations and over 400 sole proprietorships, the primary growth area, make up this sector.

Systems Integration. Revenues for 1994 were $20.9 billion. Over 1800 of the 4100 CPS firms, with more than 121,000 employees, identify their principal offering as systems integration services. Other participants in this field are manufacturers, distributors of computer and peripheral equipment, and telecommunications companies.

Consulting and Training. Revenues for 1994 were $24.5 billion, up 10% from 1993. Consulting firms have been able to market their services by advertising the related potential productivity gains. More than 30% of revenues from computer education and consulting services come from abroad and are generated by the 50 largest U.S. service providers.

Computer Programming. Revenues for 1994 were $21.2 billion and employment grew to 207,200, an 11% increase over 1993. There is high market demand for any tool that frees users to create their own applications and allows technical specialists to concentrate on large projects. The five skills in highest demand (PC and LAN systems administration, relational data base design, and UNIX, C++, and COBOL programming) are all central to the mainstream combination of PCs and mainframe systems.

Telecommunications Equipment: This IT industry sector is composed of telephone, telegraph apparatus, radio and television broadcasting and communications equipment network equipment including transmission systems multi-plexing equipment, repeaters, and line conditioning equipment, switches (telephone and microwave and data communications) and satellite systems. Total revenue for 1994 was $36.0 billion. Growth has been sluggish, reflecting excess capacity in the U.S. wired network and static demand pending development of new services. Revenues for telephone and telegraph apparatus were steady ($17.5 billion) as were revenues for radio and television broadcasting equipment ($18.5 billion). Revenues from foreign markets are increasing with Canada and Mexico as the largest export markets. Imports from East Asia, China, Malaysia, Thailand, and the Philippines, however, are beginning to supplant U.S. suppliers in Hong Kong, South Korea, Singapore, and Taiwan. The leading telecommunications import categories are facsimile machines, line telephones, and cordless telephones followed by radio transceivers, parts for radios, television transmission equipment, and cellular telephones.

Telecommunication Services: This IT industry sector consists of providers serving the communications markets for local exchanges, long distance, international, cellular and mobile radios, satellite, and data communications including value added network services (VANS) and packet and protocol conversion. Information services include on-line data bases and electronic yellow pages. There are message and conference services, specialized services, and transaction processing. This industry sector serves more than 90 million households and 25 million businesses worldwide. Industry revenues were approximately $193 billion in 1994, an increase of approximately 7% over the previous year. There are more than 2000 companies and 875,000 employees with both regulated common carriers and unregulated private network providers.

Telephone service continues to be a valuable and cost effective service for American consumers and businesses. Local service rates have not been keeping up with inflation and long distance rates have declined dramatically (31% since 1984). Local exchange carriers spent about $20 billion for construction of new facilities in 1993 and continued deployment of fiber optics in their geographic areas. Long Distance networks are already nearly 100% fiber and utilize satellite and microwave circuits for backup and special facilities applications. Both local and long distance carriers are either investing in, or are considering, digital technologies for wireless communications networks including cellular systems.

Cellular and paging revenues were $18.3 billion in 1994 and are expected to be $32.0 billion in 1998. Satellite services using fixed earth stations, include broadcasting, data transmission, and telephony, generated about $1.6 billion in 1994. The bulk of current domestic satellite capacity is used for video transmission; terrestrial cable. Fiber optics carry most domestic voice and data telephone service. Revenues from both fixed and mobile satellite services are expected to exceed $3 billion by the late 1990s. VANS, offering services such as packet transmission and protocol conversion, on-line databases and electronic yellow pages, message and conference services, electronic mail, and data interchange generated revenues of $3.9 billion in the U.S. and $15.6 billion world-wide.

CURRENT ISSUES AND EMERGING TRENDS

Convergence within the IT industry, expanding global markets, and demands for innovative technology are all creating a vast array of new issues and challenges. Highlights of cutting edge issues and trends resulting from the rapid pace of change and convergence in the IT industry include:

Technology Advances. IT technologies are maturing from research and development stages into real capabilities. These capabilities greatly improve information processing and transmission speed, for example:

Microprocessors. The heart of CPU processing power, speed, and capacity--the microprocessor--***is doubling in capability every 18 months***--at no increase in price. Microprocessor power is measured in terms of megahertz and bits. Megahertz (MHz) measure CPU processing speed and bits govern the number of discrete addresses available within the random access memory (RAM). More RAM address space allows for larger and more complex operating instructions for the computer and increases the amount of data it can manipulate (e.g., a 16-bit CPU can randomly access 65,536 address locations in RAM; a 64-bit CPU can access over 18 quintillion). Today's fastest commercially available microprocessor is the 64-bit/100 megahertz Intel Pentium processor, but a 64-bit/250 megahertz processor has already been announced.

Bandwidth. Bandwidth, measured in "bits per second" (BPS), gauges the capacity for transmitting information. In the past, signals requiring high bandwidth, such as TV, were transmitted via wireless analog radio frequency (RF) signals. Low bandwidth requirements, like voice over telephone and video (up to 150 channels) traveled by coaxial cable. The advent of fiber optic cable enables new technologies that are bandwidth hungry (e.g., interactive multi-media).

Fiber Optic Cable. Fiber optic cable is an enabler of photonics--the technology of transporting and processing information in the form of light photons instead of electrical current. Fiber optic cable provides an intrinsic capacity of 25,000 gigahertz bandwidth on each of the multiple fiber threads contained in a cable. The throughput capability of fiber is further improved by employing synchronous optical network (SONET) technology for switches and routers. SONET point-to-point and ring transmission systems form a powerful transport infrastructure for narrowband and broadband services including voice, video, and data.

Asynchronous Transfer Mode (ATM). The key to exploiting fiber optic cable is ATM, a cell-based packet switching technology. ATM breaks down and uniformly combines all forms of communication (voice, data, video, images) into digital cells of uniform size. Using switches, these uniform cells can be processed in hardware via microchips that function at gigabit (billion bits per second) speeds. With ATM it is now possible to provide real-time services (e.g., voice and video simultaneously) on one fiber cable.

Personal Communications Systems (PCS). PCS has the potential to radically alter wireless communications, by unifying voice, data, facsimile, and even some forms of multimedia under a single, universal, cost-effective umbrella. PCS will offer three major modes or types of services: *narrowband PCS, broadband PCS*, and *unlicensed PCS.*

Narrowband PCS employs frequency allocations of 900-901 MHz, 930-931 MHz and 940-941 MHz. These frequencies will be used to offer new services like

wireless voice messaging and two-way pagers.

Broadband PCS uses 120 MHz in the 1850 MHz to 1990 MHz band. Many are designed with a micro-cellular architecture where cells can be placed every few thousand feet versus eight-miles apart for cellular systems. As a result, PCS handsets can be smaller, lighter and will have excellent battery life. Broadband PCS will be used to implement an all-digital integrated voice/data infrastructure which will enable advanced intelligent networks that allow "one person, one number," service nationwide. The short distance transmission characteristics of lower-power systems should also allow excellent frequency reuse in a given area, providing much more capacity than current cellular systems.

Unlicensed PCS exists in a 40 MHz block in the 1890 MHz to 1930 MHz band and will allow unlicensed operation of short distance (and typically indoor or campus oriented) wireless voice and data devices, including wireless LANs and wireless private branch exchanges.

Signal Technologies. Time division multiple access (TDMA) technology differentiates signals by time slot and frequency which also sharply restricts the reuse of spectrum in nearby cells. The newer signal technology is code division multiple access (CDMA). CDMA differentiates signals by a spreading code which allows use of the same frequencies, at all times, everywhere. While TDMA can see only one transmission path, CDMA has "path" diversity, an ability to combine multiple weak signals into an intelligent stream. The true cost of TDMA is its inability to share spectrum. No such limitation exists for CDMA.

Satellite Technologies. Geo-synchronous orbits at 22,282 miles from earth offer a constant elevation and angle from any point on earth. It is the orbit most often used today by existing SATCOM systems, but it also imposes technical limitations. Signals in space attenuate in proportion to the distance they travel, so communications with satellites in the geo-stable Clark belt typically require large antenna or megawatts of focused beam power. Using geo-stable earth orbits (GEO) satellites, the Direct Broadcast System (DBS) will potentially reach billions of customers at the same cost as reaching millions of customers through cable TV. DBS offers many more channels and smaller antennas due to its higher transmission frequencies (higher bandwidth). While DBS offers the ability to transmit vast amounts of information to large numbers of viewers simultaneously, it is unable to offer custom programming (e.g., video-on-demand) and is not interactive like the Internet.

Low earth orbit (LEO) satellites, used in projects such as Iridium, Globalstar, and Teledesic, orbit at altitudes of approximately 435 miles. Since LEOs are nearly 60 times closer to earth, the inverse square law works in their favor. Compact, low-power handsets with small, smart antennas allow much more capability at lower cost. By being inside the Clark orbit, LEOs also expand the amount of useful room for space-

based communications.

Software. The explosion in hardware capabilities has created a demand for more robust software capabilities--a demand that is increasing software complexity and cost and is having a negative impact on quality.

Complexity and Cost. Programmers are being required to write more capable programs that perform more and more complex operations. A program for a complex application today can be *several million* lines of code in length. Writing such a program obviously takes more than one person and often requires several groups of programmers working months, and sometimes years, to complete, all at significant cost. An analytical design and programming methodology that many believe shows some promise for reducing software development complexity and cost is the object oriented approach. Object oriented programming languages reduce the need for large amounts of syntactic material. Although the complexity of the design is still present, the process is simplified because of programming uniformity, understandability, flexibility, stability, and reusability.

Quality. Producing error free software is extremely difficult and the software engineering community does not readily admit to defects. One example of emerging software quality issues is the widely reported defect called the "Pentium bug." This famous "Pentium bug" is not an engineer's design error but a programming error--an indication of today's software quality problems. The Software Engineering Institute (SEI) has designed a software development quality measurement process called the capability maturity model (CMM) that may be the long term solution to these quality problems. The CMM is a set of recommended practices that has been shown to enhance software development and maintenance capability and is based on knowledge acquired from software-process assessments and extensive feedback from both industry and government. The CMM involves determining expected results and using metrics to measure attainment of goals through five maturity levels: initial, repeatable, defined, managed, and optimizing. Results are continuously monitored through a feedback process and adjustments made as necessary.

Regulation. Current federal regulation and oversight of the industry is based on the Communications Act (CA) of 1934 and a consent decree in anti-trust litigation brought by the Department of Justice. The original CA was passed before television was commercially available, before microwave transmission, before satellites, before micro-electronics, before computers, before digital data technology, before pagers, before electronic publishing, before personal communications systems, and before transoceanic telephone cables. Over the past 60 years, there have been a few piecemeal amendments to the Act, most notably the 1984 and 1992 Cable Acts.

Communications Act of 1934. The CA of 1934 was an effort to contain the AT&T monopoly, discourage anti-competitive behavior in the burgeoning radio and

print industries, and consolidate a number of federal regulatory agencies. It created the Federal Communications Commission (FCC), which regulates many activities of communications carriers including telegraph, telephone, radio, cable television, and broadcast television, as well as cross-ownership and entry between market segments. The CA aimed to modernize and consolidate regulation of the broadcast, telephone, and telegraph sectors as they existed in 1934 and erected barriers between the various transmission modes and media. That may have been appropriate at the time, but in today's business environment, these barriers often stifle competition, innovation, and investment. Some have said that the CA's separate treatment of each market segment erected barriers to competition which created "regulatory apartheid" that now weakens all segments of the industry.

Antitrust Litigation. In 1974, the Department of Justice, in an antitrust case against American Telephone & Telegraph Company (AT&T), alleged that AT&T had engaged in anti-competitive practices in the long distance market. A consent decree, commonly referred to as the MFJ (Modification of Final Judgment), was issued in 1983 and continues to be a dominant source of federal oversight of the telecommunications industry. It provides incentives and rewards for competitive behavior and imposes sanctions for continued anti-competitive behavior by the parties. The MFJ also ordered the structural separation of the local telephone exchanges from other telecommunications services and created seven completely autonomous regional Bell operating companies (RBOCs). AT&T was prohibited from providing local telephone services while the RBOCs retained local telephone service monopolies in their respective regions. The RBOCs were required to provide long distance carriers (e.g., AT&T, MCI, Sprint, etc.) with nondiscriminatory access to the "local loop," but were prohibited from providing long distance services themselves.

Impact of the MFJ. The separation of long distance from the local monopolies increased competition dramatically in the long distance market. Residential long distance rates have fallen almost 50% and resale of long distance services is thriving. Long distance users can pick and switch among numerous carriers with complete transparency and dialing parity--gone are the days when non-AT&T customers had to use up to 23 digits to make a long distance call, while AT&T customers only had to use 10-11.

The MFJ prohibited RBOCs from: (1) providing long distance services; (2) manufacturing telephony equipment; and (3) providing information services. The variety of telephony equipment and number of manufacturers have increased, however, competition has not increased in local telephone markets. RBOCs continue to dominate because they own the "local loop." Technological developments (e.g., cellular, CATV, satellite, and microwave), however, may eventually lead to meaningful competition. These technologies have high potential for enabling competition because they can establish end-user connectivity *without* accessing the RBOC's local loop, but they are either not yet sufficiently affordable or not yet deployed in sufficient quantity

to be a real competitive threat to the RBOCs. The strongest potential competition is from the CATV industry since it already has wire into 60% of U.S. homes and has wire passing by another 30%. The CATV industry must make significant investments in two-way switching equipment, however, before it can effectively compete in the local market. Cellular telephony is also a potential competitor, but costs are still significantly higher than wired service. In addition, the RBOCs own almost 50% of the cellular carriers in the top 20 U.S. markets--a cause for some concern about increased RBOC dominance in the local telephone market.

The Cable Act of 1992. This act amended the CA of 1934 to specifically prohibit the RBOCs from providing video programming. In March 1995 the court granted one RBOCs' (Bell Atlantic) petition to lift this restriction.

Other Regulation. Unless preempted by federal law or regulation, intrastate communications are regulated by state legislatures and public utilities commissions. This includes local telephone exchange area and cable television (CATV) franchise area assignments as well as local service rate regulations. Most states have established the local telephone carrier as a monopoly in a given service area by prohibiting new entrants to the market and have also awarded exclusive franchise areas for CATV services. Several states (New York, Oregon, Nebraska) have initiated pilot programs that allow local telephone carriers to experiment in the intrastate intra-LATA (local access and transit area) toll call markets. Some states have removed restrictions against multiple local telephone carriers and CATV franchises in the same geographical area, and Illinois recently completely deregulated all aspects of intrastate telecommunications.

Pending Legislation. On March 30, 1995, the Telecommunication_Competition and Deregulation Act of 1995 (S652) was introduced in the Senate. On May 3, 1995, the Communications Act of 1995 (HR1555) was introduced in the House. Both Acts propose comprehensive reforms to laws governing telecommunications. Proposed changes include a transition period leading to almost complete elimination of legal and regulatory barriers that prevent local telephone companies, long distance carriers, CATV operators, and other communications providers from competing in each others' market with safeguards that assured interconnection and cross-access. Debates over these proposals should be heated. Industry representatives, as well as lobbyists for each market sector, express the desire for full, free, and open competition, but at the same time argue for regulation--a position that might be viewed as an attempt to preserve a traditional advantage.

Education and Training. Improving the quality of American education and training is key to maintaining our competitive lead in IT markets. Well-educated workers with strong math and science backgrounds are quickly becoming a strategic national asset. If America cannot produce quality graduates with the right skills, many countries such as India and Pakistan are willing and able to provide highly trained workers at a

fraction of U.S. wages. While U.S. curricula still reflect the educational needs of the 1930s, Europe and Asia have taken the lead in reforming their educational programs based on technological knowledge and skills needed through the turn of the century.

The U.S. does recognize this critical shortfall, however. Goal #5 of ***Goals 2000: Educate America Act*** is aimed at making the U.S. first, in mathematics and science achievement worldwide. This goal will be achieved by strengthening math and science education in primary and secondary schools and by a 50% increase in the number of math and science teachers by the year 2000.

IT companies, especially those with electrical engineering recruitment and retention problems, are also making an effort to establish partnerships with educational and academic institutions. These initiatives should be encouraged as another step towards ensuring that the U.S. will have a quality work force, with the right skill mix, necessary to retain our international competitiveness.

Information Warfare. Although the term "information warfare" tends to bring to mind conflict and combat, in its broadest sense, it also pertains to ***information competition***. The crucial discriminators between information ***warfare*** and information ***competition*** are ***intent*** and ***violence***. Information competition pertains to situations where one actor (nation, corporation, or sub-national group) uses information to obtain an advantage over a competitor versus organized attacks to destroy, compromise, or otherwise impair national information resources. Either way, information warfare describes a new warfare medium which capitalizes on the information dependence of modern societies as a means to attack them. The integrity and security of national information resources are essential to maintain a healthy national economy and to support the defense establishment which protects U.S. national interests.

Information vulnerabilities are multiplying due to the extensive, and ever increasing, national and international networking of information resources. Attacking these vulnerabilities can potentially disable large segments of economic and social infrastructures. Complicating matters is the increasing information sophistication of potential adversaries, enabling more nations and sub-national groups (many of them from the "underdeveloped" world) to obtain the information weapons capable of threatening U.S. national information resources.

The U.S. is also becoming increasingly dependent on information-intensive weapons systems. These weapons systems, which multiply force effectiveness, also multiply force vulnerabilities by providing weaker opponents a relatively easy way to undermine military strategy and operations. US military forces will not operate very well or very long if their information ***lifeline*** is severed or degraded. Information, because it maximizes effectiveness and ensures logistical support, is indispensable to the success of modern military operations. Tampering with it is the surest, easiest way to nullify our military capabilities. To counter information vulnerabilities, the DoD

is using the Personal Computer Memory Card International Association (PCMCIA) card and is considering adoption of the Commercial Key Escrow encryption capability. Each of these can and probably will be used by the private sector.

PCMCIA. The DoD has mandated the inclusion of PCMCIA card slots in future desktop acquisitions. Latest releases of the PCMCIA are aimed at laptops and notebooks and are designed to make full use of Pentium processors.

Commercial Key Escrow. DoD is considering adopting an "open key" type technology known as Commercial Key Escrow. In 1993, the U.S. Government announced its intention to adopt the Clipper Key Escrow capability as the primary domestic and export encryption methodology. Due to public concerns over the constitutionality of the "Clipper Chip" proposal (e.g, the Federal Government retained access to backup keys), the Government is evaluating the new Commercial Key Escrow capability being developed by Trusted Systems Incorporated. This methodology is similar to Clipper-like technology but removes the backup key from the Federal Government and places it under the control of other authorized organizations, such as law enforcement agencies. Existing legal/law enforcement mechanisms can then be used to gain access to backup keys.

Modeling and Simulation. Modeling is either predictive, which can be validated through experimentation and is generally used in engineering applications, or exploratory, which cannot be validated and is generally used in policy analysis. Simulation can be live, constructive, or virtual. For example, a live military training simulation is the use of real equipment in the field, a constructive simulation is the use of wargames or analytical tools that substitute for actual troop movements, and a virtual simulation is the use of stand-alone simulators to replicate the use of a weapon system. A "synthetic environment" is the combination of the three types of simulation. Virtual reality, a term increasingly in vogue, is the seamless blending of the simulation types.

Modeling and simulation provide low cost methods for dealing with complex issues. The Federal Government, in particular the DoD, has played an important role in modeling and simulation advances. This role is decreasing, however, as commercial firms reap the benefits of past DoD R&D and as the government continues to "right" size.

Fundamental enabling technologies have led to a major breakthrough in simulation--distributed interactive simulation (DIS). DIS is the integration of computerized simulation capabilities through networking. The Army's investment in development of the SIMNET (SIMulated NETwork) was key to the development of the current industry standard DIS 2.0 application level protocols. DIS allows modeling that emulates battlefield behavior by allowing large numbers of participants and provides an enhanced ability to develop terrain databases. These advances will clearly play an

important role in future special operations battle preparation. In addition, the development, testing and evaluation of new platforms through simulation is growing both in commercial and defense procurement--in fact, the Army recently directed that all procurements incorporate a Simulation Support Plan to ensure that the platform is evaluated in the synthetic battlefield environment prior to approval.

The commercial market evolves around a business sector in engineering, policy analysis, procurement, and an education/ entertainment sector. Numerous applications such as virtual golf and networked air combat simulations are already being successfully marketed. Advances in simulation are aimed at greater complexity in modeling techniques underlying the simulation, friendlier human/machine interface, decreasing costs for greater capability, and greater levels of application in all areas of personal and business life.

International Competitiveness. The IT industry is central to the improvement of U.S. productivity and competitiveness in manufacturing and services. Some critics argue, however, that U.S. export growth in these industries has not kept pace with their potential, and that the U.S. is losing ground in some key areas. To be sure, trade barriers and unfair trade practices, such as dumping and intellectual property rights violations, have impacted the U.S. trade position in these sectors, as have public regulatory practices overseas, particularly in the area of telecommunications. Nevertheless, the U.S. remains a strong global trader in these sectors. In fact, the ***Critical Technologies Update 1994,*** published by The Council on Competitiveness, reports that the United States has significantly strengthened its competitive position in critical technologies during the past five years. Software was rated "strong," the highest of four rating categories, in all areas in the 1994 report (applications software, artificial intelligence, computer modeling and simulation, expert systems, high-level software languages, and software engineering). Computers were rated "strong" in neural networks, operating systems, and processor architecture, while hardware integration was listed as "competitive."

Some progress has been made internationally in strengthening the "rules of the game" in recent years. The completion of the Uruguay Round of GATT Trade Negotiations in April 1994 included: (a) tariff reductions in many telecommunications and computer sector product categories; (b) strengthened intellectual property protection in areas such as computer software copyright and semiconductor chip production; (c) improved rules for trade in services, including information services and computer repair and engineering services; and (d) broader curbs on certain trade-restrictive investment regulations.

Japan remains the strongest competitor to the U.S., having narrowed the gap in computer equipment during the 1980s by building a strong domestic base in semiconductors and other key technologies. Most of Japan's growth has been in the area of high-volume "commodity-type" products and within its own domestic market.

Other Asian suppliers are taking an increasingly large share of global trade in "lower-end" parts and products.

Investment in Research and Development (R&D). Historically, the Federal Government has been a significant sponsor and funding source for basic R&D, particularly within the IT community. The key role played by the Advanced Research Projects Agency (ARPA) in developing what has become the Internet is a prime example of government R&D investment in IT. Today, however, the commercial market drives IT development at a pace far beyond the financial and technical capabilities of the Federal Government. As budgets continue to shrink, the Federal Government's role in Information Technology R&D will become more and more limited. In fact, the government role may be reduced to that of informed consumer of technological advances developed by private industry while market demand becomes the final arbiter of success in their implementation.

Government Acquisition Policies. The ***Brooks Act***, passed by Congress in 1965 centralized the acquisition, lease, and maintenance of automatic data processing equipment (ADPE) under the General Services Administration (GSA). The purpose of the Act was to establish the authority and the operational mechanisms needed for the effective and efficient management of costly ADPE. The three primary objectives of the Act were to (1) improve information management; (2) optimize the utilization of ADPE through sharing of assets; and (3) to provide more economical ADPE acquisition.

The ***Brooks Act*** was designed in an era of mainframe computers--an obvious mismatch with today's information technology. In fact, recent General Accounting Office reports cite the Act as a major cause of government mismanagement of ADPE (e.g., buying obsolete technology, failure to buy off-the-shelf technology, and cost overruns on ADPE contracts). Because the government is the largest single buyer of ADPE in the world (over $25 billion spend in fiscal year 1994), there is clearly still a need for oversight. But while the Brooks Act may have been the right solution 30 years ago, it is not the right solution today..

The right solution may be on the horizon specific recommendations to Congress to exempt the DoD from the Brooks Act were made in the January 1993 report ***Streamlining Defense Acquisition Laws***. Legislation to this end has been drafted by the office of Senator William S. Cohen. Because the draft has not yet been released for committee review, it is impossible to speculate on its contents or even if it will progress beyond the committee stage.

Information Superhighway. Nothing in our lifetimes, short of the idea of putting a man on the moon, has caught the imagination of the American people and the world

with such intensity as the idea of an ***Information Superhighway.*** In simplest terms, the Information Superhighway is the personification of the convergence of telecommunication, personal computer (PC), and cable television network technologies. Not to be confused with the Internet, the Information Superhighway will ultimately be the U.S. national information infrastructure--broadband, digital, and interactive. The Internet, growing at rate of more than 25% each month, allows tens of thousands of database and computer network users to communicate with each other in real time and for free (at least for the time being), and is a glimpse of how the Information Superhighway will link people and information together in the 21st century. As the Information Superhighway evolves, the Internet will ride the same lines and improve as greater bandwidth and faster transmission rates become available. Furthermore, as other nations develop their own Information Superhighways, cooperative partnerships between countries and/or multinational companies will open up access to vast IT resources, truly heralding the age of the Global Information Infrastructure (GII).

The Clinton Administration has formed the Information Infrastructure Task Force (IITF) to articulate and implement the national vision of the Information Superhighway-a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at the users' fingertips. It will ultimately have the bandwidth and speed to send photographs, music, and video clips, as well as enable much-touted applications like telemedicine, telecommuting, distance learning, and movies on demand. Every household, library, school, business, and government office from the inner cities to wilderness outposts will have full-fledged access. This vision of the Information Superhighway has been widely embraced by industry and government, however, the technology needed for it will not be cheap and most agree that the Federal Government has neither the technical expertise nor the fiscal resources to lead its development. In fact, the IITF has clearly defined four roles for the government: (1) articulate requirements as a user; (2) sponsor and encourage hi-tech research and development; (3) facilitate the meeting of key players and the exchange of ideas; and (4) fulfill legal responsibilities such as those of the Federal Communications Commission. Note that funding and financing the development of the Information Superhighway is not included as a role for the government.

Social Issues. Rapid advances and innovations in the IT industry are radically changing the very fabric of our lives--in some cases in very obvious ways and other cases more subtly. Most of these technological advances are theoretically aimed at making our lives effortless--work from home, shop from home, bank from home, videos on demand, interactive games and all at the click of a button! As with any type of innovation or change, there are opportunities--and there are threats. Changes resulting from advancements in IT are no different except perhaps for the variety and magnitude of the social implications of these changes. IT encompasses more than the Internet. The information revolution is socially all-encompassing and raises several key social issues.

Universal Access. How can you become a member of the "virtual community" if you do not have access? Access means not only having the physical hardware (computers, modems, etc.), but also having access at reasonable rates to the communications services needed to join the rest of the "Net Surfers" around the world. The access issue also involves availability of public access, for example, in schools, libraries, and other public institutions. Resolution of the universal access issue will determine whether or not IT advances will really bring people closer together or will ultimately widen the gap, perceived or real, between the "haves and have nots."

Telecommuting. "Virtual Offices" are now not only a reality, but are becoming more common as businesses realize that there are real savings in overhead costs to be reaped by allowing employees to "telecommute" and work from their homes. At the same time that businesses are recognizing the advantages of "telecommuting," they are also struggling with new challenges. How do they monitor their employees? How do they maintain esprit de corps with reduced social interaction? What type of protocols should they establish for communicating in the "Information Age" (e.g., How should an employee respond to a direct E-mail question from the CEO-electronically "staff" the response or answer directly?).

Censorship. Another social issue resulting from advances in IT is not really new--Censorship. Long a contentious issue, censorship on the Internet is causing renewed and heated social debates. At the present time there are no laws governing on-line communications, however, just as with censorship of printed materials, there are no easy solutions to this issue. In fact, the solutions will probably be even more difficult to come by, considering the international legal implications of global on-line communications.

Privacy. The flip-side to the censorship issue is one of privacy protection. Our increased ability to telecommunicate allows us to shop from our homes, do our banking, our taxes, schedule appointments, rent videos, obtain medical advice-you name it! Data from all of these on-line transactions can create quite a personal profile. The Orwellian question becomes who does, and should, have access to this type of information?

Privatization. Internationally, many countries still have government owned and operated telecommunications industries. The current trend is towards privatization and the introduction of competition, with Germany, France and Brazil leading the way. Privatization efforts are primarily modeled after the break-up of the AT&T monopoly. Competition, therefore, is expected to lower prices and improve the quality and variety of telecom services offered. U.S. companies will play a significant role in these privatization efforts because of the opportunities for global expansion, increased revenues, and their respect in the world telecom market.

Standards. Standards have long been an issue within the IT industry and are even more contentious today given consumer demands for connectivity and interoperability. The industry is responding to global market demands in the spirit of "cooperation"--a delicate balance of cooperation and competition. In order to remain competitive, businesses are focusing on compatibility rather than on developing proprietary products. This focus is the same regardless of industry sector or product. For example, software, hardware, databases, switching and transmission protocols, telephone numbers, programming languages, and computer chips are all being designed to meet standards which will gain international acceptance. Two examples of emerging industry standards are ATM ("cell" switching technology that combines the advantages of "circuit switching" used in telephony and "packet" switching used in data transmission) and SONET (a transmission protocol). Both are gaining rapid international acceptance.

The responsiveness of the industry is speeding up the traditional standards-setting process. This phenomena, however, has thus far not eliminated the need for domestic and international standards setting bodies such as the American National Standards Institute (ANSI) and the International Standards Organization (ISO).

KEY CONCERNS

The preceding discussion of current issues and emerging trends highlights the many challenges and unanswered questions facing the IT industry today. There are, however, several immediate and overarching concerns. These include:

Infrastructure Development. While it is clear that U.S. industry will install, manage, and own the Information Superhighway, the Federal Government has a critical role to play. The government's role will be as an enabler, providing the tools that industry needs to build the Information Superhighway. Removing outdated regulations that stymie innovation, investment, and competition will be the first serious test of the government's role in reshaping U.S. IT policy. The Information Superhighway initiative has focused industry and government towards greater cooperation that will enhance America's competitive advantage in the IT industry. The concerted efforts of industry and government will elicit a competitive response among U.S. companies that should result in new and improved consumer products being brought more quickly to the market.

Interconnection and Access. It is generally acknowledged that comprehensive, nondiscriminatory access (unbundled interconnection) to all components (hardware and software) of the local telephone networks is required if consumers are to have choices, and real competition is to flourish across the Nation's telecommunications system. Such interconnection and access already exists in the long distance market. If every telecommunications competitor has equal or nearly equal access to every telecommunications consumer, market forces will create more competition in an effort to satisfy the consumers' needs and demands. Associated issues are dialing parity

and telephone number portability that give customers the same convenience and manner of service without regard to which vendor is providing the service.

Cross-Market Entry. Given that existing technology is converging the telecommunications industry into the transmission, routing, and receiving of bits and bytes, there is little business justification for existing barriers against local telephone companies providing long distance telephone service, CATV service, electronic publishing service, or broadcast service. However, until the local loop is opened to competition or is otherwise fully accessible to other segments of the industry, there is concern that the RBOCs will use their awesome local market power to improperly distort competition in other markets.

Universal Service. There is a clear consensus among all market sectors that universal, affordable, and reliable service should be available to everyone. A question remains on how to define universal service in light of available technology and foreseeable future technological advancements. Most would argue that a "voice dial-tone with touch-tone" service should be the baseline with a goal of transitioning to fully interactive "video dial-tone" service. This is a solvable issue and will probably be the subject of FCC rulemaking after extensive comment from industry and consumers.

Another, more difficult question is the methodology for funding universal service to schools, libraries, rural areas, and other customer segments that may not be cost effective. At present, universal service is subsidized by business customers and by charges to the long distance carriers for accessing the local loop to complete a call. Most would agree that future funding for universal service ought to be apportioned in an equitable, competition-neutral manner among all market segments. Almost no one agrees on exactly how that can be done.

Privacy and Security. Privacy issues are generally thought of in the context of government access to confidential information owned by or concerning an individual or a business. While that remains a concern, with a ubiquitous telecommunications network there is also significant concern about non-governmental users gaining unauthorized access to that information. Industrial espionage, trade secrets, credit card fraud, and medical record confidentiality are just a few of the real concerns relating to the privacy issue in the information age. The most practical solution to these problems is some type of encryption hardware or software that will control who can access the data. In the meantime, there is likely to be federal legislation imposing specific criminal and civil sanctions for using elements of the telecommunications system to intentionally gain unauthorized access to confidential data or to make any unauthorized alteration or distribution of confidential data.

Intellectual Property Rights. One of the greatest challenges facing U.S. commercial software companies is illegal copying of their products, that is, software piracy. In 1989 foreign sales by American software companies were approximately $12 billion

while losses due to foreign piracy were estimated at between $7 to $9 billion. Software piracy is a larger problem overseas, but there is also a piracy problem in the U.S. with the losses due to illegal copying and use estimated at $2 billion. Software piracy ranges from making illegal copies and selling them, to unauthorized copying of personal computer software at home or in the office. Unauthorized copying is the most frequent piracy in the U.S. and accounts for more than half of the $2 billion in revenues lost by the industry. Software piracy is an issue because development costs are spread among a smaller base of users which results in higher single copy costs. It also reduces overall revenues; consequently less funds are available for reinvestment in research and development.

RECOMMENDATIONS

The very nature and pervasiveness of Information Technology makes the industry itself a matter of national security. It is now widely acknowledged that information is a key element of national power--both independently, and integrally as a driver of political, economic, and military elements of power. Many recommendations concerning what role the government should play, if any, are implicit in our previous discussions of issues, trends, and concerns. In general, U.S. laws, policies, and regulations should promote continued technical innovations and the accompanying capital investments required to stimulate growth, promote real competition, and sustain U.S. leadership in the IT industry. To be effective, a *National Information Policy* should be established which addresses the following goals:

1. Full recognition that U.S. Information and Information resources are a vital national interest.

2. A U.S. that is able to produce or obtain all information and information resources, even in nonpermissive or denied environments, needed for effective and efficient operation of the national security, public, and private sectors.

3. A U.S. that is not dependent upon other nations for the elements of National Information Power.

4. A U.S. Government that plays an active role in ensuring a viable and healthy information and information technology base.

5. Identification of specific areas of the U.S. industrial base constituting the information and information technology base.

6. Development of dual-use information technologies.

7. Achievement of at least a two-generation lead in information technologies.

8. Development and maintainenance of the most sophisticated information security capabilities in the world.

9. Identification of vital national information resources (e.g., banking, research and development, scientific, industry) and ensuring their protection.

To facilitate achievement of these *National Information Policy* goals, we offer the following specific recommendations:

Deregulation. Rapid and orderly deregulation of the telecommunications and broadcasting industries, along the lines of legislation currently before the U.S. Congress, is essential. Deregulation will ultimately release the creative potential of the IT industry and ensure continued U.S. leadership worldwide.

International Market. The U.S. Government must ensure that U.S. IT companies enjoy fair access to foreign markets. This includes supporting deregulation and privatization abroad, protecting intellectual property rights--a major source of American competitive advantage in the industry-and working towards international standards which are fair and beneficial to American industry.

Information Security and Privacy. Despite a growing worldwide demand for products to improve information security and privacy, current U.S. export controls restrict sales abroad of sophisticated American encryption technologies and software, allowing foreign competitors to reap the profits. The U.S. Government should foster the development of information security technologies which are based on market solutions and on public key encryption, and permit sales abroad. At the same time, the government must invest wisely to maintain its lead in encryption technology. U.S. national security demands that the government, not the private sector, remain the world leader in this area.

Research and Development (R&D). There are several R&D areas where judicious investment of scarce government resources can produce significant dividends. R&D investments in the IT industry should be focused on providing: (1) seed money to support basic scientific and technological research and (2) funding for applications research in areas critical to national security (e.g., encryption and decryption, defense-related simulation and modeling, and military communications).

Education. The U.S. Government must ensure that Americans have the skills essential to survive in an information-based global economy. These skills include basic computer literacy and basic public access to the Information Superhighway (e.g., via schools and libraries). The government must also partner with industry to develop retraining programs to create relevant skills for those workers displaced by automation and economic restructuring. Finally, as the pace of technological change continues to accelerate, we must embrace the notion of lifelong learning--both to

protect against technological obsolescence and to cultivate the full benefits that IT offers.

CONCLUSIONS

There is clearly a sense of urgency both inside and outside of government concerning the information technology explosion and the management of cyberspace. These are more than just new issues-they are new *types* of challenges. This study has attempted to capture not only the economic and technical aspects of the Information Technology industry, but also to convey the sense of excitement and continuous change it generates. It provides a snapshot in time of a dynamic and revolutionary industry--IT literally *is* everywhere!

This is a good news story: the IT industry is exploding and the United States enjoys global leadership in most industry sectors. The opportunities associated with this industry and its technologies are endless-what remains to be seen is how the United States will choose to capitalize on them.

APPENDIX A

IT INDUSTRY SECTOR PERFORMANCE (1994 ACTUAL/1998 PROJECTIONS)

INDUSTRY SECTOR	1994 INDUSTRY REVENUES $478.2 B	PEOPLE EMPLOYED AND APPROX NO. OF FIRMS	PREDICTED 1998 REVENUES $631.6 B (+7%)
COMPUTER EQUIPMENT	$60.0 B	190,000 Pers TOP 100 Firms DOMINATE	$67.5 B (3%)
COMPUTER SOFTWARE AND NETWORKING	$53.4 B	200,000+ Pers	$80.8 B (11%)
Prepackaged Software	$34.5 B	155,000 Pers	$58.7 B (13%)
Networking Equipment	$ 7.4 B	800 LAN Firms 5400 Products	$ 8.3 B (3%)
CAD/CAM/CAE	$11.5 B	U.S. has 2/3 world market	$13.8 B (4.6%)

APPENDIX A, Cont'd - *IT INDUSTRY SECTOR PERFORMANCE*

INDUSTRY SECTOR	1994 INDUSTRY REVENUES $478.2 B	PEOPLE EMPLOYED AND APPROX NO OF FIRMS	PREDICTED 1998 REVENUES $631.6 B (+7%)
INFORMATION SERVICES	$135.8 B	1,000,000 Pers 25,000 Firms	$211.8 B (13%)
Electronic Information Services	$ 15.6 B	2200 firms	$27.3 B (15%)
Data Processing	$ 53.6 B	Many firms(<50 pers). Some large(>20k pers)	$90.5 B (14%)
Professional Services		4100 firms and over 400 sole proprietorship	
Systems Integration	$ 20.9 B	121,000 Pers 1800 firms	$29.5 B
Consulting/ Training	$ 24.5 B	Many small independents	$34.6 B
Custom Programming	$ 21.2 B	207,200 Pers	$29.9 B

APPENDIX A, Cont'd. - *IT INDUSTRY SECTOR PERFORMANCE*

INDUSTRY SECTOR	1994 INDUSTRY REVENUES $478.2 B	PEOPLE EMPLOYED AND APPROX NO OF FIRMS	PREDICTED 1998 REVENUES $631.6 B (+7%)
TELECOM EQUIPMENT	$36.0 B	200,000 Pers (declining)	$40.5 B (3%)
Telephone and Telegraph (Switches,Fax, Telephones)	$17.5 B		$19.7 B (3%)
Radio and TV Broadcasting (Fixed/mobile, Cellular,Sat)	$18.5 B		$20.8 B (3%)

APPENDIX A, Cont'd. - *IT INDUSTRY SECTOR PERFORMANCE*

INDUSTRY SECTOR	1994 INDUSTRY REVENUES $478.2 B	PEOPLE EMPLOYED AND APPROX NO OF FIRMS	PREDICTED 1998 REVENUES $631.6 B (+7%)
<u>TELECOM SERVICES</u>	$193.0 B	875,000 Pers 2000 Firms	$231 B (4-5%)
Long Distance			
-Domestic	$58.0 B	480 Firms	$73.0 B (5-6%)
-Interntl	$12.3 B		$15.5 B (6%)
Local Carrier	$96.0 B	43 Local, 14 Toll, 30 Access	$100 B (1%)
Value Added Networks	$3.9 B Growth Area	6 Firms have 50% of Market	$5.0 B (14%)
Cellular and Paging	$18.3 B Growth Area	Major Local and Long Distance Firms	$32.0 B (15%)
Personal Communications Services (PCS)	Growth Area	224 Experiments Authorized	Potential Market $14.0 B by 1999
Satellite Services	$ 2.3 B	6 Firms	$ 3.0 B (6%)
Miscellaneous	$ 2.2 B	Various	$2.5 B (3%)

REFERENCES

"A Feeding Frenzy in European Telecom," Business Week, November 21, 1994.

"Agenda for the Future," Business America, August 1994.

Allen, Robert E. CEO, AT&T Corp., Reflections on the Sixtieth Anniversary of the Communications Act, Vol. 47, No. 2, FCLJ December 1994.

Angel, David P. and James Engstrom, "Manufacturing Systems and Technological Change: The U.S. Personal Computer Industry," Economic Geography, Vol. 71, No. 1, January 1995.

Anstrom, Decker, President, National Cable Television Association, Testimony before the House Subcommittee on Telecommunications and Finance regarding HR 3636, February 2, 1994.

Baatz,E.B, "Out-of-this-World Software," Chief Information Officer, 15 February 1995.

Bane, P.W., *et al*, "International Carriers: Benchmarking Performance". Telecommunications, February 1995.

Barrett, Andrew C, Commissioner, FCC, Deregulating the Second Republic, Vol. 47, No. 2, FCLJ, December 1994.

Bell Atlantic Forms Unique Alliance to Provide "One-Stop Shopping for Large Businesses," Press Release, March 14 1995.

Blustein, Paul, "Billion-Bit Memory Chip Developed by NEC", The Washington Post, February 14, 1995.

Chong, Rachelle B. Commissioner, FCC, Trends in Communications and other Musings on Our Future, Vol. 47, No. 2, FCLJ, December 1994.

Clendenin, John L, Chairman and CEO Bell South, Clear the Path to Competition, Clear the Path for Everyone, November 14, 1995.

Communications Act of 1934, 47 U.S.A. 151 et. seq.

Communications Act Reform, Department of Commerce White Paper, 1994.

"Corporate Scoreboard," (1994 Corporate Performance Indicators), Business Week, March 6, 1995.

Crandall, Robert W, After the Breakup: U.S. Telecommunications in a More Competitive Era, Washington, D.C., The Brookings Institution, 1991.

Critical Technologies Update 1994, Council on Competitiveness, Washington, D.C.: September 1994.

Deutsch, Peter, "Bandwidth too Cheap to Meter," Internet World, January 1995.

Druffel, Larry and George H. Heilmeier, "Acquiring Defense Software Commercially," Report of the Defense Science Board Task Force, Office of the Under Secretary of Defense for Acquisition and Technology, Washington DC, June 1994.

Economic Impact of Deregulating U.S. Communications Industries, WEFA Group, February 1995.

Garten, Jeffrey, "Trade, Technology and America's Interests in a Changing World Economy," Speech to the Computer and Communication Industry Association, Washington, D.C., March 8, 1994.

Gates, William H. Microsoft Corporation President's Letter to Shareholders, February 1995.

Gibbs, W. Wyat, "Software's Chronic Crisis," Scientific American, September 1994.

Gilder, George, Life After Television: The Coming Transformation of Media and American Life, New York, NY, W.W. Norton and Company, Inc., 1994.

Gilder, George. *"Telecosm: Etherspere,"* Forbes ASAP, January 1995.

Gomes-Casseres, Benjamin, "Computers: Alliances and Industry Evolution," Beyond Free Trade, edited by David Yoffie, Harvard Business School Press, Boston, MA, 1993.

Gordon, Scott V. and James M. Bieman, "Rapid Prototyping: Lessons Learned," IEEE Software, January 1995.

Gore, Albert, Speech to the G-7 Ministers Meeting on the Global Information Initiative, Brussels, Belgium, February 25, 1995.

Gore, Albert, Speech to the Television Academy, January 11, 1994.

Gross, Nail and Peter Coy, "The Technology Paradox: How companies can thrive as prices dive," Business Week, March 6, 1995.

Hadden, Susan. Chairman, Policy Committee, Alliance for Public Technology, Testimony before the Senate Committee on Commerce, Science, and Transportation, May 24, 1994.

Hill, Eileen, "Strong IPR Protection is Important for High-Tech Trade," Business America, August 1994.

Hiltz, Starr Roxanne and Murray Turoff, The Network Nation: Human Communication via Computer, Cambridge, MA, The MIT Press, 1993.

Hollings, Fritz, U.S. Senate (D-SC), Hollings Pushes New Communications Reform Measure, Press Release, February 15, 1995.

Hylton, Lori, "System Integration Services Enhance U.S. Global Competitiveness," National Trade Data Bank electronic report, Washington, D.C., 1994.

"Industry Survey: CI/ROMTEC Top 50 1993," Communications International, January 1994.

Jones, Capers, "Quality Quest," Chief Information Officer, February 15, 1995.

Kato, Yuji and Sam Paltridge, "Telecom Tariffs and the Move to Markets," OECD Observer, No. 191, December 1994/January 1995.

Keen, Peter G. W. Every Managers' Guide to Information Technology: A Glossary of Key Terms & Concepts for Today's Business Leader. Boston, MA, Harvard Business School Press, 1995.

Kennedy, Paul, Preparing for the Twenty First Century, Vintage Books, New York, 1994.

Kitfield, James, "Is Software DoD's Achilles' Heel?," Military Forum,

July 1989.

Krol, Ed, The Whole Internet, Sebastopol, CA, O'Reilly & Associates, Inc., 1994.

Kupfer, Andrew, "The Future of the Phone Companies," Fortune; October 3, 1994.

Lebow, Irwin, The Digital Connection: A Layman's Guide to the Information Age, New York, NY, W. H. Freeman and Company, 1991.

Malison, Andrew, "Microprocessor Industry: Developments Influencing Global Competition," National Trade Data Bank electronic report, Washington, D.C., 1994.

Mathias, Craig and Peter Rysavy, "The ABC's of PCS," Network Wireless World, November 7, 1994.

McBee, Gary, Chairman, Alliance for Competitive Communications (RBOC trade association), speech before the Washington Research Group Telecom Legislation Workshop, March 3, 1995.

Mocenigo, Anthony J, "The U.S. is a Major Force in the Global Fiber Optics Market," Business America, August 1994.

Noam, Eli M, Principles for the Communications Act of 2034: The Superstructure of the Infrastructure, Vol. 47, No. 2, FCLJ, December 1994.

Paltridge, Sam, "Judging Telecom Performance," OECD Observer, No. 182, June/July 1993.

Pressman, Roger, "Software According to Niccolo Machiavelli," IEEE Software, January 1995.

Pressler, Larry, U.S. Senate, Chairman, Senate Commerce, Science, and Transportation Committee, Draft Legislation, (Telecommunications Competition and Deregulation Act of 1995), discussion draft, February 1, 1995.

Regulatory Environment Impacts Emerging Personal Communications Industry, report prepared by U.S. Department of Commerce, International Trade Administration.

Reich, Robert B, The Work of Nations, New York, Vintage Books, 1992.

Reidy, Chris, "Satellite-TV System blazes a hot trail," The Boston Globe, reprinted in The Virginian-Pilot and The Ledger Star, January 31, 1995.

Reilly, Edward T, President, National Association of Broadcasters, testimony before the House Subcommittee on Telecommunications and Finance regarding HR 3636, February 2, 1994.

Rheingold, Howard, The Virtual Community: Homesteading on the Electronic Frontier. Reading, MA, Addison-Wesley Publishing Company, 1993.

Schwartz, John, "On-Line Obscenity Bill Gains in Senate: Panel Backs Legislation; Critics See Threat to First Amendment," The Washington Post, March 24, 1995.

Senate Committee on Commerce, Science, and Transportation Hearing, "Competitiveness of the U.S. Software Industry", U.S. Government Printing Office, Washington D.C., November 13, 1991.

Shebalin, Paul V, "Software Development Standards and the DOD Program Manager," Acquisition Review Quarterly, Summer 1994.

Smith, Raymond W., Chairman and CEO, Bell Atlantic, Bell Atlantic Chairman Calls for Streamlined Regulation Governed by the States, press release, February 28, 1995.

Speakers to the Telecommunications/Information Systems Industry Study and Senior Acquisition Group, Industrial College of the Armed Forces, Class of 1995.

Stedman, Craig, "Rising European Tide Lifts Systems Makers," Computerworld, October 24, 1994.

Stowe, Ronald F, Vice President, Pacific Telesis Group, Every Customer, Every Service, Every Competitor, Telecom Reform in the 104th Congress, NS/EP Telecom News, February 1995.

"Telecommunications" (Special Industry Survey), The Economist, October 23, 1993.

"The Computer Industry" (Special Industry Survey), Economist, September

17, 1994.

"The Fortune 500 Ranked by Performance," Fortune, April 18, 1994.

"The Global Money Machine," U.S. News and World Report, December 12, 1994.

The National Export Strategy: Annual Report to Congress, U.S. Department of Commerce, Trade Promotion Coordinating Committee, October 1994.

The National Information Infrastructure: Agenda for Action, Information Infrastructure Task Force, Department of Commerce, September 15, 1993.

The New Realities of the Communications Marketplace, Vol. 47, No. 2, FCLJ, December 1994.

"The Technology Paradox," Business Week, March 6, 1995.

Toffler, Alvin and Heidi Toffler, Creating a New Civilization: The Politics of the Third Wave, Washington, D.C., The Progress and Freedom Foundation, 1994.

Toffler, Alvin and Heidi Toffler, War and Anti-War: Survival at the Dawn of the 21st Century, Boston, MA, Little, Brown & Company, 1993.

Trawinski, Lori A, "U.S. International Transactions, Third Quarter 1994," Survey of Current Business, December 1994.

Tyson, Laura D'Andrea, Who's Bashing Whom? Trade Conflict in High Technology Industries, Washington, D.C., Institute for International Economics, 1992.

U.S. Industrial Outlook 1994, U.S. Department of Commerce – International Trade Administration, Washington, D.C., U.S. Government Printing Office, 1994.

U.S. Telecommunications Trade in 1993, NTDB Report prepared by U.S. Department of Commerce, Office of Telecommunications.

United States v. American Telephone and Telegraph Co., 552 F. Supp. 131 (D.D.C. 1982), *aff'd sub nom.*, *Maryland v. United States*, 460 U.S.

1001 (1983).

Vijayan, Jaikumar, "Glowing Results Overshadow PC Concerns," <u>Computerworld</u>, October 24, 1994.

INDUSTRY STUDY

#18

TRANSPORTATION

TABLE OF CONTENTS

PARTICIPANTS

Students:

CAPT Brian W. Blanchfield, USN
LTC Brian W. Davenport, USA
LTC Joseph P. Donnelly, USA
Dr Deborah F. Frank, D/A
COL Margaret N. Guerrero, USMC
Lt Col Lynn M. Harris, USAF
CAPT Robert H. Jackson, USN
Ms Terri L. Jendrossek, USCG
LTC Yerry M. Kenneally, USA
Lt Col Gregory L. Lockhart, USAF
Ms Brenda A. Parker, DOT
CDR Craig W. Patten, USN
Mr William H. Pugh, Jr., CIA
Lt Col Robert K. Saxer, USAF
CDR Peter Squicciarini, USN
Col Michael Wansink, CF

Faculty:

Col Anita M. Arms, USAF
CAPT Jack V. Smith, Jr., USN

PLACES VISITED

Domestic

United Parcel Service, Hub Tour,	Burtonsville, MD
CSX Intermodal	Hunt Valley, MD
CSX Intermodal Terminal Facilities	Port of Baltimore, MD
AMTRAK, National Railroad Passenger Corporation	Washington, D.C.
CONRAIL, Pittsburg to Philadelphia CONRAIL Train Trip	
AMTRAK, Philadelphia to Washington, D.C	
Amtech Corporation	Dallas, TX
Con-Way Truckload Services	Fort Worth,TX
Frozen Food Express Industries, Inc.	Dallas, TX
American Airlines	Dallas/Fort Worth Airport
Burlington Northern Railroad	Dallas, TX
Sea-Land Corporation	Dallas, TX
Alliance Development Company,	Fort Worth, TX
Santa Fe Railway, Alliance Intermodal Hub	
Nokia Corporation, Alliance Intermodal Hub	
Zenith Corporation, Alliance Intermodal Hub	
Federal Express	Memphis, TN

International

Rotterdam Port Authority	Rotterdam, Netherlands
Royal Ned Lloyd Group	Rotterdam, Netherlands
Sea-Land Corporation, Delta Terminal	Rotterdam, Netherlands
Europe Combined Terminals (ECT)	Rotterdam, Netherlands
Military Traffic Management Command - Europe	
Dutch Rail Service Center	Rotterdam, Netherlands
French National Railroad (SNCF)	Paris, France
Charles de Gaulle Airport	Paris, France
Sea Containers (SEACO)	London, United Kingdom
Maersk	London, United Kingdom
EUROTUNNEL, Folkstone	Kent, United Kingdom
Heathrow Airport Authority	London, United Kingdom
British Airways, Heathrow Airport	London, United Kingdom

NOTHING HAPPENS TILL SOMETHING MOVES

Nothing impacts each and every part of our life more than the ability to get what we want, when we want it! Whether it's the proper blood for a critical operation, a required part for the B2, or simply the right dress or shirt, we tend to take for granted that what we want will be readily available when needed. This hasn't always been the case, but is increasingly the type of service we expect and demand from our global economy. In fact, this universal availability of goods is something all of us expect, without much thought as to how it happens.

But the process of moving goods from the point of manufacture to the point of sale or use affects both cost and availability. And as this process becomes more and more seamless and efficient, an entire industry is evolving into a multi-billion dollar business of transportation, storage and asset visibility. Loosely grouped for purposes of study into an industry called intermodal transportation, this doesn't really do the process justice. It's much more than transportation! What the Transportation Industry group really studied this semester had less to do with planes, trains, trucks and ships, and more to do with an evolving and changing process that's rapidly migrating toward the most efficient combination of transportation modes to meet the needs of the customer. This includes both the federal government and military, where traditional roles of transportation and distribution are being challenged by the efficiency of firms such as Federal Express (FedEx) or CSX/SeaLand.

And in a sense, this industry has been a victim of its own success. Because now as goods move from all over the world to any market the competition to transport those goods is intense. This press of increasing global competition and the resulting squeeze on corporate profits has forced the use of the most efficient means to move goods, regardless of the mode. And in this global, demand driven economy nothing happens until something moves!

To understand just what this means, imagine standing in a Nordstrom store and shopping for a dress or shirt. This particular item of clothing happened to be made in the Ningxia region of China, and just 13 days earlier was still a bolt of cloth. But here, on this day, it's just the thing you want to buy, and how it got to Nordstrom is really the process we want to discuss.

To do this, we visited or were briefed by a number of firms from Dallas to Rotterdam. A detailed list is contained in Appendix A. What we found was an industry in transition, a process evolving in an almost revolutionary fashion from the stovepipe modes of air, rail, sea and road transportation to providing a seamless service of one-stop shopping to meet the customer demands of reliability, cost, and timeliness. This report will look at the

following areas: the industry today; its conduct, behavior, and performance; the problems and barriers to growth; an assessment about the future and implications for national security; and finally some conclusions and recommendations. The structure of this industry, however, is still built around planes, trains, trucks and ships, and so we must first look at them.

PLANES, TRAINS, TRUCKS AND SHIPS

Transportation is big business, accounting for about 17 percent of GDP and slightly more than 10 percent of all national employment. 1 And, of course, the mainstay of transportation has long been the vehicles that do the transporting. But as the distances over which goods must travel have steadily increased, it's become the exception to use just a single mode. And as multiple modes are now efficiently used to bridge the physical constraints of land-sea and air-land boundaries, factors such as minimizing handling times and tracking cargo location are just as important as how it moves, probably more so in the eyes of the customer.

Developments in the areas of transportation technology, distribution logistics including storage and warehousing, containerization of cargo, proliferation of hub-and-spoke systems, and developments in information technology all help facilitate getting that dress or shirt to Nordstrom. And in fact it's likely that the clothing will arrive on the store display floor ready for sale; having been hung on racks and price-tagged in China, moved from China to the Nordstrom store in Virginia by truck, ship and rail, and without ever spending time in a warehouse. Let's look at the structure of the industry today.

Air. Movement by air is generally considered the smallest segment of the transportation business, accounting for just 0.3 percent ton-miles of freight moved. 1 But the speed and globe-shrinking characteristics of this mode make it highly competitive in the passenger business and in the "overnight" delivery market. U.S. airlines, however, were buffeted by major financial losses that began in 1990 and continued through 1993 as they struggled to regain profitability and develop long-range stability. During 1993, major carriers concentrated on three strategies to achieve financial stability. Firstly, they reduced capacity by limiting new aircraft orders and stretching out deliveries. Secondly, many negotiated major labor agreements with their unions to lower unit costs while labor assumed a larger equity share in a number of airline companies. And thirdly, airlines attempted to establish more reasonable yields and a more stable fare level.

These strategies produced modest long-term growth, with revenue passenger miles projected to grow about 3.9 percent a year through 2004. U.S. carriers expect even greater gains in international traffic, which is forecast to grow an average of 6.6 percent a year through 2004.

The air-cargo industry is composed of airlines that specialize in providing air express or general air freight service. It's also made up of airlines, including passenger airlines, that provide contract, charter, or scheduled cargo services to the shipping public, and to other cargo airlines. Competition and the need for greater efficiency have spurred the creation of highly automated sorting hubs supported by a network of aircraft and ground

vehicles, such as at Federal Express in Memphis.

U.S. carrier participation in international aviation includes the operations of scheduled and non-scheduled airlines, all-cargo carriers, and air freight forwarders. While the airline and air cargo industries suffered a deep slump through much of the early 1990's, all signs point to growing profitability. And, as with ships there is no lack of capacity to move passengers and cargo by air.

Rail. The U.S. railroad industry made a remarkable recovery following deregulation in 1980. Since then freight traffic carried by the U.S. railroad industry has increased by 50 percent. Last year it hauled 1.2 trillion ton miles, which represented 38 percent of the market share.1 The main reasons the railroad industry increased its freight traffic so dramatically are increased productivity and reduced costs, thus becoming more competitive. Today there are 12 Class I railroads (railroads with annual operating revenue of at least $254 million), which account for 91 percent of all the freight railroad revenue. The railroad industry hauls more freight than any other individual transportation segment.

Railroads must also bear a huge burden in the overhead of their infrastructure. During the 1980's, U.S. railroads spent over $30 billion in improved rail, crossties, ballast, signals, computers, new generation locomotives, and innovative rolling stock. Railroads must continue to shoulder this burden if they expect to be productive and competitive, but the movement of goods by rail is a booming business and shows no signs of slowing.

But while we use rail to move cargo efficiently over long distances, AMTRAK's passenger rail service remains unprofitable. Intercity travel by rail doesn't compete well with air travel in the U.S. due to the distances and time involved, except in the Northeast Corridor. Because of this the Europeans are able to claim a considerable advantage due to the effectiveness of high speed passenger rail.

Road. 1980 also saw the deregulation of the trucking industry, which has undergone a huge change since then. Deregulation removed the entry barriers and allowed new, non-union carriers to enter the market place. The number of trucking firms in the U.S. stands at over 50,000 today.

The trucking industry can be broken down into three overlapping sectors; private carriers, for-hire carriers, and exempt carriers. Exempt carriers haul specialized cargo, such as unprocessed agricultural products, and are exempt from Interstate Commerce Commission (ICC) routes, area, and rates. The market share is more widely distributed than in the railroad industry. The largest five carriers in the U.S. trucking industry are all for-hire carriers, yet they account for only a small percentage of total industry operating revenues.

In contrast to railroads, the trucking industry is able to take advantage of the highways supported by government funding. Federal-aid highways have a network of over 843,000 miles and qualify for federal funds for construction, resurfacing, and reconstruction. The federal-aid highway system comprises about 22 percent of all roads in the U.S., but carries 81 percent of all highway traffic.1 The trucking industry makes up a good portion of that highway traffic and shows every sign of remaining a large and

important part of the transportation business.

Sea. The maritime shipping fleet includes both liner and bulk-trade vessels. Ships are often considered to be the start of the intermodal business because this is where mass containerization of cargo was started more than 40 years ago. The liner segment varies considerably in size and during the early 1980's underwent major ownership changes. In the aggregate, gross tonnage of liners increased by approximately 40 percent during the past decade. At the same time, the composition of the fleet changed from small, general-cargo carrying vessels to mostly larger, full and partial container ships, including the roll-on/roll-off (RO/RO) and lighter-aboard-ship (LASH). As the fleet became more container-oriented, the liner companies have become extensively involved in offering intermodal service in conjunction with rail and road carriers. This led to an industry-wide practice of partnering in order to promote mutual success through trust and cooperation in long-term relationships.

Merchant ships of many nations compete, to varying degrees, in various segments of the maritime industry. A significant number of factors, including governmental maritime policies, trade route traffic volume, and industry capacity affect the nature of that competition. World trade volume has increased nearly four times during the past two decades, and during that time the capacity of the world's maritime fleet expanded by nearly 250 percent. Eighty percent of these vessels are involved in the movement of bulk cargo and the balance consists primarily of container ships.

The U.S. flag fleet of commercial size ships (1,000 gross tons and over) contains about 390 privately owned ships and 225 government owned merchant ships (192 freighters), most of which are inactive and laid up at national defense reserve fleet sites. The U.S. fleet ranks 10th in the world in gross tons and isn't generally considered a major factor in international commerce. Private U.S. ships are relatively more important in the container trade (with 92 container ships, 52 partial container ships, 50 roll-on/roll-off vessels, and 19 barge carriers), ranking 6th in the world in this area. 1 However, these U.S. fleet rankings are likely to fall because U.S. vessels aren't being augmented by new purchases. Recently, while 601 ships were added to the world fleet, no new ships were added to the U.S. fleet. This, combined with the reflagging of U.S. ships to avoid high domestic labor costs, spells trouble for the U.S. fleet. However, there is a worldwide over-capacity of merchant shipping availability and over-water transport will continue as a key segment of intermodal transport.

Newer trends. But the structure of the industry is also characterized by some trends which, for example, allow clothing arriving at Nordstrom to be placed on the display floor without ever being in a warehouse. This is possible through an organizational innovation often called just-in-time (JIT) delivery. This isn't a new concept but has really developed in response to increasingly complex customer requirements that force suppliers to closely integrate production and logistics. The object is to reduce inventory and throughput times by using real time collection of information to accurately forecast actual needs. This type of "rolling warehouse" actually tends to reduce congestion because the only goods transported are those really needed.

The task of procuring high quality, flexible service at an acceptable price is a major challenge for many transportation buyers. Traditionally, many buyers focused on

selecting the low cost carrier, not the service-oriented one. In an effort to include service performance and quality in the transportation purchasing process, a growing number of transportation buyers have adopted strategies and tools from other fields. Two areas which have demonstrated the ability to provide a dual focus on service improvement and cost reduction are industrial purchasing and quality assurance. The industrial purchasing discipline has provided a number of sourcing strategies--supply base optimization, longer-term contracts, longer-term relationships, commitment to total quality management, all of which are critical for success. These strategies have been adopted by transportation purchasers in the form of carrier reduction efforts, open-ended contracts, core carrier programs, and partnership initiatives. An industry wide re-emphasis on quality has improved timeliness and reliability of shipments.

Now that we've explored the basic structural segments of the transportation industry we can examine the overall conduct of this business.

FROM REGULATION TO COOPERATION

Our transportation system functions as a network that links virtually every point to all other points by many different modes of transportation. However, it also depends on and functions best with effective intermodal connections.

The conduct and behavior of today's transportation industry is best characterized as a migration from regulation to cooperation and is being significantly influenced by a rapidly growing optimization of advanced technology and digital information systems. During the past decade, technological advances in everything from satellite communications and mobile navigation to smart hubs have made it possible to pro-actively control much of the chaos and uncertainty that historically accompanied cargo movement. Freight managers who once used pick tickets and pay phones for cataloging and tracking shipments now rely upon on-board computers and electronic data interchange (EDI) for real-time progress and position updates.

The significance of these technological advances marks an important evolution for the transportation process. For the first time in history, the nation's carriers can pinpoint the immediate location of goods in shipment. Truckers and railroads can track and deploy containers and other equipment as they move among different rail lines and highways and across different modes. This means that these carriers are achieving significant productivity gains by consciously merging advanced information systems with their long-haul vehicles in a cooperative venture toward greater efficiency and customer service. For both customer and carrier alike, this means better value and lower cost. And for the industry it signals advanced technology's critical role in the movement of freight.

The industry initiatives of just-in-time logistics, improvements in total asset visibility (TAV), and enhanced in-transit visibility (ITV) have unlimited potential for increasing transportation efficiency. The demand for these services is growing steadily and intermodal companies are responding. Companies such as CSX/SeaLand have invested significant capital in hardware and infrastructure, including purchasing new and improved containers, constructing specialized rail cars, operating multimodal freight terminals with their requisite platforms and large cranes, making roadbed improvements to ensure the

smoother ride necessary for containerized freight, and improving rail line clearances to handle larger double-stack equipment.

Government deregulation served to eliminate unproductive routes and renegotiate labor agreements to reduce staffing levels and increase scheduling flexibility. Deregulation also opened the door to partnerships, and while there have been some mergers and acquisitions among trucking companies, railroads and maritime shipping lines more frequently they have established partnerships, either through joint ventures or contractual relationships. Passenger transportation, which is more dependent than freight transportation on public sector programs and funding, has moved less quickly to intermodalism.

Intermodal transportation is clearly one of the keys to improving the productivity and competitiveness of U.S. industry while at the same time improving our quality of life and overall environment. Intermodalism accomplishes these dual goals by ensuring the most efficient modes of transportation are used in each stage of movement, and use of the most efficient mode is in the public interest. A shift from trucks to trains for example will help reduce air pollution, save fuel, and cut congestion on highways. This will reduce the number of highway accidents and lower highway maintenance costs.

Because of this, government takes an active role in encouraging intermodal transportation. The federal government took the first step with the **1991 Intermodal Surface Transportation Efficiency Act (ISTEA)**, which requires planning to integrate all modes into national, state and local systems. One of the important criteria for designating roads as part of the new National Highway System is whether they provide access to ports, airports or other intermodal terminals.

As states develop intermodal plans, they address several key questions, the most important of which is how well the existing publicly owned road and bridge system serves movements. States first look at access. Railyards, where many intermodal terminals are located, don't always connect with the highway system. Trucks have a hard time getting to the rail yards to deliver goods. As a result, states focus on improving road connections. Improving access may require construction of new thoroughfares, possibly dedicated to commercial use. Or it could mean upgrading existing roads so that they can better accommodate trucks. Existing roads and bridges impede efficient operations in other ways and grade crossings have long been a source of conflict between rail and highway users. Also, many separated crossings have overpasses with clearances that cannot accommodate double-stack trains.

Roadway clearances are not the only impediment to double-stack movement. Sometimes the required improvements are on railroad-owned property. Some states are using public funds to help railroads deal with this problem. To preserve the competitiveness of the Port of Philadelphia, for instance, Pennsylvania identified corridors in which it desired double-stack service and then subsidized the railroads' removal of obstacles and roadbed improvements.

New rail connections may also be required, especially near ports. Without those connections goods that arrive in major ports often have to be trucked over congested urban thoroughfares to reach rail terminals. It's estimated that trucks carry 500,000

containers a year over heavily traveled freeways between the ports of Los Angeles/ Long Beach and railroad terminals near downtown Los Angeles (the Alameda Corridor). To achieve better rail access into ports, states may be called upon to yield right-of-way along existing roadways or on public land. They may use eminent domain powers to help private interests acquire property needed for the right-of-way or to develop access directly.

The role of government should be in planning and policymaking that encourages and accommodates intermodalism. Passage of ISTEA ushered in a new era of choice and freedom for the states in dealing with transportation. Under ISTEA, state transportation agencies and their Metropolitan Planning Organizations (MPOs) have more flexibility than ever before in managing their programs and are freed from what many believed was unnecessary federal interference and bureaucratic delay. Shifting from laws and regulations which emphasized modal operations, ISTEA offers a strategic vision for U.S. transportation policy: "to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner." Unfortunately, while ISTEA's planning provisions encourage states to consider these issues and options, its funding provisions are restrictive. States can only use the federal funds to plan intermodal facilities and to build roads to those facilities. States may be able to provide space for rail lines but only if the right-of-way for those lines is part of a highway project.

Congress charged the National Commission on Intermodal Transportation (NCIT) in ISTEA, with investigating the intermodal transportation system of the U.S. Their final report to the Congress in 1994 recommended making efficient intermodal transportation the goal of federal transportation policy.

There is also the question of whether the public sector - the federal government in particular - should set standards for equipment and informational technology. Such standards would definitely help the intermodal transfer process work better, though it might also hamper the innovative development of equipment and interchange agreements tailored to meet customer needs. However, as the intermodal network expands, safety is and must always be a key consideration.

With the background of the transportation industry's structure and conduct now complete, let's look at its recent performance.

GETTING THE JOB DONE

The performance of the transportation business is driven by areas of influence involving intermodalism, global competition, and intermodal trends and strategies.

Intermodalism. Intermodalism is the process of using multiple modes of transportation to complete a single movement while obtaining the best possible service at the lowest cost. Simply put, economics has driven the industry toward efficiency, with control and accountability critical to the movement of goods between modes. Increased competition in all areas of the transportation industry necessitated that every aspect of the

business be reviewed and changed as required. And it's a growth business; intermodal traffic volume tripled from 1975 to 1994.

An efficient transportation system allows manufacturers to keep merchandise costs down and remain competitive in a global market. Containerization and rapid intermodal connections have eliminated the double and triple handling of cargo, further reducing damage and pilfering, which have taken their toll on tight profit margins. Across the industry the standard for damage free loads stands above 99 percent. CSX Intermodal reported in 1991 that 99.8 percent of all loads were handled damage free.

Global competition. Global competition has led the transportation business to begin partnering with each other and with manufacturers and retailers to take advantage of market strengths, routes, and maximize carrying capacities. On the domestic scene, the transportation industry has reacted positively to the potential offered by NAFTA, GATT, and the loosening of trade restrictions worldwide. Opening the Canadian and Mexican borders provided incentives to motor carriers and rail lines to invest in new trade. On the other hand, the severe financial crisis in Mexico has delayed full intermodal involvement. Virtually all motor and rail carriers are patiently sitting on the Mexican border awaiting the stability necessary to expand business.

The impact of the express carriers such as FedEx, UPS and others has changed the complexion of cargo movement in the U.S. and overseas. Transportation companies now compete not only for the small package business, but also for the larger LTL (less than truckload) and TL (truckload) business in the "premium", or rapid delivery category. Expedited delivery of small packages, once the domain of a small number of companies, is now attracting others (such as the Postal Service) to enter into this niche market. Providing "time definite" intermodal truckload transportation is a new and important market. Many of the established partnership agreements have the express purpose of providing coast-to-coast and international capability to move large shipments in an expedited fashion.

Intermodal trends. The following trends characterize the industry today:

Electronic Data Interchange: Advanced technology in the fields of digitization, fiber optics, micro-electronics, and computerization provide the means of controlling and accounting for intermodal shipments. Electronic data interchange (EDI) is the computer-to-computer exchange of business transactions that conforms with specified standards over a communication network that includes at least two trading partners. EDI provides the infrastructure necessary for critical transactions. Elements of data processing, business processes, and communications are combined in EDI. EDI is as much an evolutionary catalyst for continuous improvement as it is an information system. EDI improves internal company performance and external relationships with suppliers, customers, and carriers. EDI allows intermodal companies to re-engineer business practices to eliminate non-value added processes and provide customers with what they need. Customers want to know what's in the box as well as where the box is located.

Transportation logistics managers are faced with the challenge to manage and control equipment utilization. Many intermodal marketing companies (IMC) contend that equipment utilization is the key industry issue today and treat it as a priority.

One way of managing and monitoring intermodal equipment assets is through fully integrated EDI and communications systems. EDI enhances the matching of the delivery process with the pick-up process. The combination of price sensitivity, global manufacturing and distribution, and precise service requirements places considerable pressure on carriers. The challenge to transportation companies is to find ways to help their customers remain competitive. Those IMCs which survive in the new transportation environment will be large, technologically advanced, and capable of sustaining strong and long-lasting intermodal partnerships. Some applications of EDI are:

Customs Clearance. EDI can reduce delivery time for imported shipments. The import data and customs documentation are electronically transmitted to the international customs service for approval. Customs personnel begin processing the information before shipments arrive, reducing paperwork and speeding documentation and turnaround time. For example, Atlanta-based United Parcel Service (UPS) uses this system with China and has reduced customs clearance by one day, which may make the difference in keeping or losing a customer.

Third Party Logistics/Outsourcing. Many intermodal companies possess shipping expertise, but may lack the computer skills and programming expertise to develop and implement successful EDI systems. The result is often the contracting of a third-party for logistics. Third parties can yield considerable benefits in flexibility through sophisticated communications and EDI capabilities that can be used without the prime company investing in equipment that will soon be obsolete. There are often reduced labor costs through outsourcing logistics.

Intermodalism is the mechanism that makes the just-in-time management technique work. JIT brings merchandise and material to a store or factory just as the goods are required. This heavily transportation sensitive system eliminates the costs of maintaining on-hand inventory, warehousing, and inventory control. The transportation mode becomes the warehouse and in-transit visibility is the inventory control. As major corporations reduce overhead and costs, and concentrate on their core competencies, they are turning to third party logistics firms for distribution and warehousing functions. An example is the relationship between Toyota and American President Lines (APL). Toyota Camry parts from Japan are delivered to Toyota's Kentucky assembly plant just hours before needed on the assembly line. Intermodalism is growing because transportation is a core competency of most third party logistics firms and offers value to the customer. Outsourcing of logistics means the manufacturer or retailer does what they do best and allows the specialized third party logistician to do what they do best; cost optimize the distribution system through the use of the most effective and efficient means of transportation.

Cash Management Operations. An important part of intermodalism is making sure the bills get paid. Many transportation companies have developed single point electronic payment programs. This system links transportation providers and customers electronically instead of relying on the customers now inefficient hand-processing of checks. The company maintains control over disbursements and eliminates check processing costs.

For example, FedEx eliminated billing headaches with General Electric Information Services' EDI platform called the GEIS System. While the transition to an EDI system did not result in a reduction of employees, it did enable FedEx to handle increased volume without increasing staff.

In-Transit Visibility (ITV). ITV has become a major concern for shippers and carriers alike. Again, economics dictated that ITV be explored and employed. With just-in-time procurement techniques taking hold, it has become more important for consumers to know where their material is at any particular time. Industry has taken this interest seriously and is leading the way in development of acceptable and affordable methods of tracking. The business objective is simple -- to provide a system for automated worldwide monitoring, analysis and reporting of the movement of transportation equipment using the most advanced AEI (automated equipment identification) data capture technology available. Seamless transportation exists when one mode of transportation terminates and transfer of the equipment to the next mode can be immediate and virtually transparent. EDI ties the entire intermodal process together from origin to destination with complete tracing capability.

Companies such as UPS and FedEx have mastered ITV processes. Their clerks use computers to communicate with the shipper to find out not only that the package arrived, but the time it arrived and the name of the person who signed for it. Companies who use intermodal transportation and/or ITV have seen a significant reduction in inventory costs as they move to a just-in-time inventory management system.

Equipment.

Containers. As the industry continues to react to customer requirements, the size of containers being offered is dictated by demand and are continuously being improved. The TEU, or twenty foot equivalent unit, is the industry standard of measurement. Today 40, 48 and 53 foot containers are also readily available. Half height containers and even 10 foot long containers are available for shipments that most effectively travel this way. The greatest constraint to the movement of outsized containers overseas are the tunnel and bridge clearance restrictions for rail and the lack of chassis available to accommodate extended containers.

In the U.S., the luxury of double stacking containers on rail cars has become a standard practice that is not enjoyed in the overseas markets. The increased use of double stacked container trains has added to railroad's intermodal profitability by doubling their capacity. With recent tunnel and bridge clearance modifications, nearly all U.S. railroads can accommodate the height requirements for double stack movements. Railroads throughout America have invested in intermodal improvements and expansions to accommodate additional container traffic. The Santa Fe Railroad has 19 major intermodal hubs and has expanded its intermodal market reach by adding 13 hub centers through haulage agreements with other railroads. From 1992 to 1994 Santa Fe invested approximately $140 million in intermodal terminal improvements.

Refrigeration. Increased intermodal reliance has fostered dramatic improvements in the manner in which refrigerated cargo is moved. Standard refrigerated containers, known as "reefers", can move by motor, rail or water with little concern for

compatibility in maintaining required temperatures. The normal electrical and/or diesel generator hookups are common. Today, portable diesel generators can be "hung" on a container when utilities may not otherwise be available for containers staged in an austere environment, allowing uninterrupted service.

Self contained reefer units that are designed to accommodate the less-than-truckload (LTL) customer have been developed. These LTL units are staged at a customer's facility and palletized cargo is loaded. The unit is then picked up in the same manner as any other LTL shipment, providing greater flexibility and less cost than would be incurred by utilizing a full reefer truck. Specially designed reefer containers are capable of segregating freeze cargo from chill and dry cargo through the use of a "partition" system in the box. Again, this provides a new and extremely cost efficient method for both the shipper and the carriers.

Intermodal strategies. Large national long haul truck companies like J.B. Hunt, Schneider, and United Parcel Service (UPS) are moving containers (COFC) and trailers (TOFC) on flatcar generally on routes of more than 700 miles. Faced with increasing tonnages and high turnover of drivers, ranging from 50 to 150 percent, major truck lines are becoming the railroads' biggest customers for long haul movements. TOFC and COFC reduce the average per mile cost of moving freight by highway from $1.34 to about .92 cents per mile by rail. Additionally, a reduction in driver turnover will decrease expensive costs of training new drivers and lessen the driver inexperience factor out on the highway. J.B. Hunt's goal is to reduce driver turnover and the need for trucks with sleeper cabs by eliminating over-the-road long haul movements.

The development and investment in extremely efficient container handling equipment at ports, rail yards and intermodal hubs has greatly enhanced the speed and efficiencies of containerized operations. J.B. Hunt developed a container chassis system which allows up to five empty chassis to be stacked on top of each other for transport in the redistribution of chassis trailers. Competition is driving transportation companies to come up with innovative ideas to improve service and keep costs down. CSX Railroad is developing an intermodal system called the "Iron Highway," which allows TOFCs to be driven off a rail car at virtually any grade crossing, thus adding to the flexibility of intermodalism. Southern Pacific has developed the "RoadRailer" system which has a set of rail trucks under the trailer chassis, allowing the highway trailer to travel on the rail and rapidly convert from rail to highway. These rail technology innovations are geared to expand the intermodal rail market by attracting the 300 to 700 mile traffic, with quick and easy load and off-load capabilities and cost competitive prices.

In the ocean container transportation industry there were a number of large company partnerships established over the last year; Ned Lloyd, APL, MOL, and OOCL have formed a strategic partnership, as have Maersk and SeaLand. There is a common theme among major service organizations of long term commitment to quality service and customer satisfaction, even at the cost of profits.

Companies like FEDEX and UPS have become integrated partners of many mail order retailers, like L.L. Bean and Lands End. This allowed FEDEX to decrease the cost of moving a package from $19.94 in 1983 to $12.30 in 1993. UPS and FEDEX are great examples of intermodal transportation companies which maximize the most cost efficient

mode of transport. Through the use of dedicated on-line computers at customer locations and 1-800 type access, a single point of contact can track down a shipment anywhere in the system.

Large scale merchandizing companies like Best Buy, Circuit City, and WalMart take advantage of large economies of scale, buying in volume and using full intermodal containers to receive goods. The efficiency of the intermodal transportation system has given these high volume distributors a competitive advantage over smaller retailers.

SOME BUMPS IN THE ROAD

Reaching the full economic potential of intermodal transportation remains problematic even with the strong push of customer demand, added government emphasis, and the changes in the industry's culture. There are still several formidable barriers to entry into the intermodal market. The most significant stumbling blocks to increased intermodal participation fall into four main categories. They are: 1) The structural barriers such as the lack of adequate intermodal infrastructure and equipment; 2) high labor costs; 3) the level of government involvement and intervention in both funding and regulatory roles; and 4) the continuing modal culture of the transportation industry as a whole. All of these barriers are recognized and potential remedies are being pursued. Will these remedies be enough to bring more of the industry into intermodal operations? This section will look at the most significant barriers to the intermodal business and discuss the prospects for their reduction or removal based on current trends.

Infrastructure. One of the major barriers to new intermodal operators is the lack of adequate intermodal infrastructure. The National Commission on Intermodal Transportation's (NCIT) 1994 final report stated: "The weakest links in the current transportation system are the points of transfer between modes. And, because the current system is funded and managed separately by each mode, responsibility for strengthening these links is unclear." 2

The connections between the modes are plagued by congestion and inadequate access to highways at ports and rail terminals. There was no thought given to eventual intermodal integration when the current transportation infrastructure was conceived. There are real estate and land allocation problems facing each mode, making the intermodal linkage of seaports to rail, to road, and to airports increasingly difficult. Rail and highway rights of way are scarce and prohibitively expensive in just those populated areas where the connections are most needed. Airport and seaport expansion projects suffer the same ills. And all major transportation projects are bedeviled by environmental concerns.

As a result of ISTEA legislation, the NCIT recommended targeting infrastructure development funds to those "missing links and connections."3 President Clinton's FY95 Budget included a sizeable investment in transportation infrastructure ($28B of the total $39.5B DOT budget), though this was reduced by Congress as a result of the deficit reduction fever in Washington.

Even if the total DOT budget request had been approved, however, it would not have been sufficient to take care of just the traditional infrastructure system needs. According to DOT, 100,000 of our bridges (1 in 6) are either structurally deficient or functionally obsolete and need major work. More than half (58 percent) of U.S. roads are described as being in "poor" or "fair" condition by a private transportation research group, while vehicle traffic is expected to rise by 60 percent over the next two decades and government spending on transportation infrastructure is declining as a percentage of GDP.4

In a sense we are like the little Dutch boy, but the dike has ten times as many holes as we have fingers. It's no wonder that key intermodal projects requiring large public investment, such as the Alameda Corridor connection between the Port of Long Beach and the intermodal railyard in Los Angeles, have trouble getting off the ground. Given the competition for scarce federal dollars, and our continuing deficit problems, it is likely that infrastructure needs requiring public funding will continue to be significantly underfunded for the foreseeable future. Commercial capital for investment is also in short supply due to the thin profit margins resulting from the fierce competition within the industry.

Equipment problems must also be resolved. The introduction of new, more "intermodal friendly" equipment is lagging. High speed passenger trains, such as France's 180 mph TGV and Eurostar trains cannot run on present U.S. rail track infrastructure. New, more efficient trucks and planes are very expensive to capitalize into fleets, as are modern container ships or passenger ferries. Even the basic infrastructure element of container equipment is undergoing extensive evolution beyond the original international standard 20 and 40 ft dry boxes. Larger (45, 48, & 53 ft) and specialized containers that don't all fit on standard rail cars or on container ships are emerging in the world's growing 8 million container fleet creating more difficult challenges for intermodal operators.

There are some small rays of hope on the horizon regarding these structural barriers, however. ISTEA legislation and the resulting NCIT report both emphasized infrastructure needs. The commission also recognized that public funding alone will never be able to close the gap between need and fulfillment. They recommended expanding innovative public and private financing methods for projects with specific emphasis on public/private partnerships.

Some of the 340 Metropolitan Planning Organizations (MPOs) are availing themselves of this new found federal flexibility to fund key local projects through more creative means, but it's a slow learning process.

Expansion of the financing options should have a positive effect on the overall transportation infrastructure, but may not help some of the intermodal projects of national significance, since the MPOs tend to have a local focus. That is why continuing federal funding and involvement in key intermodal projects is crucial. Without public and private partnering, the needed improvements to the intermodal infrastructure will not happen, and enticing new participants into the intermodal business will be difficult. This partnering, however, will have to be done carefully since heavy government involvement and intervention in any industry is a well-known disincentive for business.

Labor. The cost of labor is an additional challenge to intermodal operators in the U.S. Next to the initial capital investments for an intermodal system, it's the largest single recurring cost and represents about 30 to 40 percent of transportation operating costs. The wages of unionized rail workers and merchant mariners in the U.S. are not competitive with those in other nations and increase costs for U.S. operators.

Industry's response to excessive labor costs has been aggressive downsizing of their workforce by taking advantage of increased automation and, in many areas, outsourcing specific labor requirements. Ocean carriers are reflagging ships offshore in order to sail with cheaper foreign crews. U.S. labor is now in direct competition with foreign labor in international trade. One of the more ominous implications is the expected lack of U.S. merchant mariners available to man the Ready Reserve Fleet.

Government Involvement and Intervention. The Government (federal, state, or local) discourages entry into intermodal transportation in two basic ways: through overregulation or confusing/conflicting regulations; or through inconsistent application of funding and/or financing restrictions.

Over the last twenty years, the general trend for the transportation industry has been toward less regulation as evidenced by the deregulation of the rail, airline and trucking industries. However, each industry still must cope with some level of regulation, and extensive government involvement by the Department of Transportation, the Interstate Commerce Commission, the Federal Railroad Administration, the Federal Highway Administration, the Federal Aviation Administration, the Federal Transit Administration, the Environmental Protection Agency, and many others. This regulatory maze still surrounds new transportation projects and mystifies and discourages potential new entrants.

On top of that, "intermodal projects are typically more complex than single-mode projects. As a result, conflicts are likely to be even more complicated and time-consuming than for traditional modal projects."5 As is apparent from the above list of Federal agencies (as they existed before the 1995 DOT reorganization), regulations have been made by modal organizations usually without regard for how they would impact another mode.

In addition, transportation projects are also subject to the jurisdiction of Federal agencies outside DOT such as the EPA, Energy, Agriculture, Commerce, State, Labor, and other departments which often conflict with transportation priorities and each other. For example, port dredging projects to improve sea access have repeatedly been thwarted by EPA requirements. Counting on the Federal Government to resolve these regulatory conflicts between agencies or to quickly modify regulations that make it difficult to operate in multiple modes has not proven to be a smart bet in the past. Industry remains skeptical, even with the Administration's strong emphasis on "Reinventing Government".

A further disincentive to cha[illegible]g headfirst into the growing intermodal market is the tremendous dependence on Government funding for most transportation infrastructure projects. Government spending (Federal, State, & local) equals about half of the overall investment in transportation each year. With estimates of over $300B needed just to fix infrastructure deficiencies, even maintenance of the system would be impossible without

government funds. However, government funding levels have been historically unreliable. In addition, the funds usually come with many spending restrictions which limit flexibility in applying these funds. This government intervention and disruption have made participating in an intermodal project by a private enterprise a risky business.

Drafters of ISTEA legislation recognized these problems and encouraged major funding reforms to include increased flexibility and more local control of how the money is spent. While these recommendations provide the promise of change, many of the age-old problems still exist. For example, although ISTEA directs concentration on intermodal projects, "funding still comes out the old way - via modal silos."6 The NCIT report also cites the difficulties encountered while trying to finance construction of bus bays at the train station in Everett, Washington. The FHWA denied funding because "it wasn't a highway project," and the FTA denied it was a transit project. Thus another intermodal effort that could have encouraged more operators to enter the market fell between the cracks of the modal transportation system.

Pushing for more state and local control of funding should ensure the application of money to meaningful local projects. On the other hand, each of the 340 separate MPOs have different structures, procedures and priorities for deciding on transportation projects. It's likely the same intermodal carriers will need to operate in areas controlled by many different MPOs and require their support. So while increasing the role of MPOs is laudable, it could discourage intermodal operations due to the requirement to interface with so many diverse government entities.

While the federal government is placing more emphasis on intermodalism, the remnants of the old modal culture remains in both government and industry.

The Modal Culture. As the NCIT final report stated, "changing thinking, institutions, and human behaviors, in many ways, are more difficult than investing in infrastructure. " 7

A significant barrier to potential intermodal operations is the continuing modal state of mind in the transportation industry itself. Although there are many who operate intermodally in business niches within the industry, some companies still view themselves as either trucking, rail, sealift, air cargo, or airline entities who have some intermodal business. Therefore, it's natural to see other modal operators as competitors and not partners. The competition between modes, especially trucking and rail, has always been stiff. And even though some are breaking through that barrier to collaborate (J.B. Hunt & Santa Fe and Schneider's RoadRailers), many can't get past the history to make intermodal work like it could. As one industry observer wrote, "In intermodal, there are too many players with too many separate agendas. It's like a relay team passing the baton with people who don't like each other." 8

Although intermodalism is practiced more now than ever, there remains a lack of a systems engineering approach to intermodal transportation. Companies tend to optimize for their own operations without regard to the effect on the overall system. J.B. Hunt's non-standard 53 ft containers and Schneider's RoadRailer concept are two examples of the intermodal "boutiquing" that is eating away at some of the operational efficiencies, and that keep other small carriers from jumping in.

ISTEA legislation and the NCIT report recognized the problems of the modal culture and provided the needed push toward change. But, altering the modal way of life for most in the industry is a slow process. Until the change in thinking is more complete, the connections between modes will remain outside anyone's responsibility and continue to be the weakest link in the chain and a large barrier to entry.

In the 19th Century, the lack of a systems approach resulted in an unusable rail transportation system for the Confederacy that contributed greatly to its eventual defeat. Without an overall industry and government commitment to an integrated systems approach to intermodal transportation, potential new players will continue to face a system with too many seams to work optimally. They will see intermodal links regionally optimized rather than integrated with the rest of the nation's infrastructure. Local priorities will overshadow those of national importance. And competition between modes and intermodal carriers could result in an explosion of specialized equipment, greatly reducing the inherent efficiencies of intermodalism.

WHERE WILL IT LEAD?

Despite the previously mentioned bumps in the road, the outlook for the transportation industry in general, and intermodalism in particular, is positive. The rapidly expanding global economy is driving increased customer demand for more efficient, cost effective, and reliable transport of goods. As a result, many former "single mode" operators who competed directly with each other have little choice but to form partnerships capable of intermodal transportation to satisfy customer needs. In addition, real progress is being made to shrink some of the barriers to intermodal operations. Finally, advances in technology such as automated asset tracking, satellite communications, and Electronic Data Interchange (EDI) are directly enhancing the efficiency and ease of intermodal moves.

The increasing customer demand for more efficient transport is evident in the fact that intermodal freight business has more than doubled since 1980[9] and is projected to continue growing at 7-8 percent per year for the next several years.[10] Although the benefits of intermodal transportation have been touted for more than 20 years and recent growth is impressive, actual implementation progressed slowly.

However, the trend toward partnering is evidence that some of the long standing barriers to intermodalism are falling. For example, trucking companies and railroads now understand they need each other. Although they still compete for some hauls, they realize that a combination of transportation modes is more economical for their customers. As a result the traditional "modal" culture of transportation is being left behind. The Department of Transportation's 1995 reorganization should also contribute to further break the modal habit. This new emphasis on intermodalism in both industry and government will likely result in more attention to the infrastructure needs at the intermodal linkages that are so critical to the operation of the transportation system.

In addition, prospects of further reduction to intermodal transportation regulation are promising. In its final report, the National Commission on Intermodal Transportation identified federal regulatory activities and the modal organizational structure of the

Department of Transportation as one of the major barriers to intermodal development in the U.S. primarily because it is outmoded. As a result of the Commission's study, several recommendations were presented to help lessen the burden of federal regulations including:

- Development of federal policies which foster private sector freight intermodal systems and reduce barriers to the free flow of freight, particularly at international ports and border crossings;

- Adoption of federal policies that foster development of an intermodal passenger system incorporating urban, rural, and intercity service, including a viable intercity passenger rail network;

It's clear that technology advances in transportation support systems, such as asset tracking and EDI, will continue to enhance the performance of intermodal transportation. Advances in information systems and automatic equipment identification allow customers to know exactly where their shipments are at all times. With this knowledge, businesses improve their inventory management and reduce operating costs.

While most of the picture for the future of intermodal transportation is bright, there are a couple of caution signs we need to watch. The U.S. passenger rail system (AMTRAK), which isn't really intermodal, continues to be in trouble, losing millions of dollars each year even though it's heavily subsidized. Without continued subsidies it's likely that only the profitable Northeast Corridor could be saved from extinction. For the shipping lines the high cost of U.S. labor is continuing to drive them to reflag their vessels offshore, which could have disturbing consequences on the availability of U.S. merchant mariners during the next major conflict. Most importantly, the infrastructure needs of the U.S. transportation system continue to be grossly underfunded and without some creative methods of public/private combined financing this vital circulatory system for the U.S. may negatively impact national security in the future.

WHAT DOES IT MEAN FOR NATIONAL SECURITY?

Our national security is directly linked to our ability to transport personnel, equipment, and supplies quickly and reliably. Any change to the transportation system that we depend on to do this has definite implications for our future security and will impact the way DoD does business on and off the battlefield.

As commercial transportation systems move toward intermodalism and become more efficient, and the Defense budget continues to shrink, we will be compelled to rely upon commercial systems for a larger portion of the needed military lift and logistics support. Current full mobilization lift requirements for commercial industry are: airlift, 50 percent; sealift, 68 percent; and CONUS rail, 88 percent. All future contingency and operational planning must account for this reliance and ensure confidence in the commercial system's ability to meet DoD's needs. In addition, the commercial system's growing use of containers requires that mobility planners and equipment developers plan shipments and new equipment to fit the standard containers. Using commercial carriers will also allow just-in-time (JIT) delivery of logistics support and supplies to military units.

Proper use of JIT, along with the anticipated advances in asset tracking, should allow significant reductions of inventory, in-theater handling and storage requirements, and reduce redundant orders that drive up transportation requirements needlessly.

As already mentioned, the trend in shipping lines is toward foreign flagging to avoid the high costs of U.S. crews. Additionally, many U.S. Civil Reserve Air Fleet (CRAF) participants are partnering with foreign carriers to share both cargo and passenger routes. This increased involvement of foreign carriers and crews in U.S. commercial transport means there may be less U.S. flagged capacity in both airlift and sealift for the next contingency or conflict. An approach to best use the foreign flagged carriers is needed before the next crisis occurs.

It's important for DoD to continuously monitor the transportation industry's health and status and to adapt security planning to accommodate any changes in direction. We can only maintain and enhance our global power projection capability by anticipating the changes and adapting operations to them. Government and commercial partnering in the transportation process will almost certainly be required.

CONCLUSIONS

With the increasingly global nature of business activity, industrial producers will seek out the highest quality, most efficient and most economical suppliers, sub-suppliers and labor from a growing pool of international sources. As we have found in our industry study, this phenomenon is having a marked effect upon the transportation industry as components and sub-components of production may cross nations and oceans a number of times before the final product is assembled or marketed. That manufacturers can afford to transport these components more economically than to have them produced indigenously is a very positive indicator of the efficiency gains that have been made in the transportation sector and underlines the importance of transportation to virtually every global and domestic industry.

The analysis of the industry in this report has led to a number of pertinent conclusions. These are:

-The industry is in the process of significant change - change driven predominantly by global and domestic competition, and technology convergence.

- Domestic and international regulation is both an asset and liability to the adaptation to change and market penetration. The significantly improved competitiveness of the rail freight and trucking industries in the U.S. is largely attributable to deregulation. Moreover, this deregulation has spurred the growth of intermodal partnerships. At the same time, restrictions to foreign partnership by both domestic and foreign regulatory bodies have impeded further competition, efficiency and economy. This is particularly true of the air carrier sector.

- In contrast to the positive effect deregulation had on the growth of competitiveness, government intervention to facilitate investment in infrastructure renewal and intermodal interfaces has been fractured and uncoordinated between government levels and

departments. The forecast is for largely insufficient investment by federal, state and local governments to upgrade of decaying road and bridge infrastructure and intermodal terminals.

- Technology, particularly in the EDI, ITV and TAV realms, has been a significant driver of efficiency and reliability gains in the industry. However, some of the technology remains to be standardized on a global scale. Once done, this will add further to efficiency, economy and competitiveness.

- Deregulation has changed the wage structure of the transportation labor sector in trucking, rail and air industries in order for competition to be effective. However, American flagged ships cannot compete with the low wages of foreign carriers under present legislation. This may impact the availability of sufficiently trained merchant mariners to man the U.S. Ready Reserve Fleet.

- The growth in the intermodal market has stimulated the growth of secondary supporting industries in logistics, warehousing, distribution centers, freight forwarding and outsourcing of intermodal operations. The fact that there has been such rapid growth in these logistics support sectors suggests a pending shakeout among the most hungry competitors and the failure of those that do not take maximum advantage of the intermodal connections where available.

- Industry can transport goods and people faster, cheaper and more flexibly than can government transporters.

- While the CRAF fleet will remain sufficient to meet DoD contingency needs, the reflagging of the U.S. sealift fleet will give the U.S. government the choice of making special compensation to domestic sealift operators to retain the U.S. flag or forge special security agreements and contracts with foreign flagged carriers to satisfy their sealift requirements in times of emergency.

RECOMMENDATIONS

Opportunities for significant additional breakthroughs in efficiency are possible. To achieve this both industry and government will need to make some adjustments.

Actions for industry. We recommend that industry:

- take maximum advantage of new technologies in ADP to provide optimum asset visibility and interface with the customer;

- continue to forge partnerships with multimode operators, both domestically and internationally;

- look to private and non-government sources for the upgrade of special infrastructure such as intermodal terminals and intermodal equipment; and

- forge agreements on the standardization and interoperability of equipment.

Actions for government. We recommend that government:

- facilitate global partnerships through standardization of equipment and technology, and encouragement of private investment. The latter may be achieved by tax incentives or grants;

- privatize government transportation operations and logistics activities where possible and profitable;

- develop incentives for private ownership and funding of major infrastructure renewal projects and intermodal linkages in recognition that there will be insufficient federal, state or local funds to renew the aging infrastructure or develop the intermodal terminals required for significant efficiency gains;

- simplify and deconflict the regulatory environment between levels of government and individual departments;

- make a decision with regard to the reflagging of U.S. vessels. The choices are to restrict the reflagging with compensation to the carriers for the non competitive wage rates or alternately to allow reflagging with specific commitment from foreign flagged carriers for their availability in contingency operations. We recommend the latter.

ENDNOTES

1. Bureau of Transportation Statistics. Transportation Statistics Annual Report 1994. Department of Transportation. Washington, DC. 1994. pp 31-32.

2. National Commission on Intermodal Transportation Final Report, "Toward a National Intermodal Transportation System", Sep 94, p 9.

3. Ibid, p 6.

4. Miles, G. "Road to Ruin? America's Neglected Highway System is Threatening U.S. Global Competitiveness", International Business, Jun 93, p 29.

5. National Commission on Intermodal Transportation Final Report, "Toward a National Intermodal Transportation System", Sep 94, p 19.

6. Ibid, p 15.

7. Ibid, p 17.

8. Richardson, H. "Remove Delays, Improve Drayage Efficiency", Transportation & Distribution, Jan 94, p 25.

9. Editorial, "Delivering the Goods", Governing, Jul 94, p 65.

10. Thomas, J. "Chasing Equipment on Intermodal Lines", Distribution, Apr 94, p 39.